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(12) **United States Patent**
Castro et al.

(10) **Patent No.: US 9,271,737 B2**
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(54) **AUTOMATIC SURGICAL LIGATION CLIP APPLIER**

(75) Inventors: **Salvatore Castro**, Raleigh, NC (US); **Curtis Thornton**, Pittsboro, NC (US); **Lynn Willett**, Raleigh, NC (US); **Michael Ramsey**, Raleigh, NC (US); **Philip Schmidt**, Roxboro, NC (US); **Dan Monahan**, Raleigh, NC (US); **Adam Lehman**, Northford, CT (US); **Paul Whiting**, Wake Forest, NC (US); **Leland Ray Adams**, Ansonia, CT (US); **Alan Bachman**, Milford, CT (US); **Steven Morris**, Cary, NC (US); **Bradley J. Labarbera**, Raleigh, NC (US)

(73) Assignee: **TELEFLEX MEDICAL INCORPORATED**, Research Triangle Park, NC (US)

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(21) Appl. No.: **13/618,215**

(22) Filed: **Sep. 14, 2012**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

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A61B 17/128	(2006.01)
A61B 17/122	(2006.01)
A61B 17/29	(2006.01)
A61B 17/064	(2006.01)
A61B 17/28	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 17/128*** (2013.01); ***A61B 17/122*** (2013.01); ***A61B 17/1285*** (2013.01); *A61B17/0643* (2013.01); *A61B 2017/2845* (2013.01); *A61B 2017/2912* (2013.01); *A61B 2017/2929* (2013.01); *A61B 2017/2936* (2013.01); *A61B 2017/2937* (2013.01)

(58) **Field of Classification Search**

CPC A61B 17/128; A61B 17/122; A61B 17/1285; A61B 2017/2936; A61B 2017/2929; A61B 2017/2912; A61B 17/0643; A61B 2017/2845; A61B 2017/2937

USPC 227/175.1–182.1; 606/142–143, 205, 606/207; 600/104, 129

See application file for complete search history.

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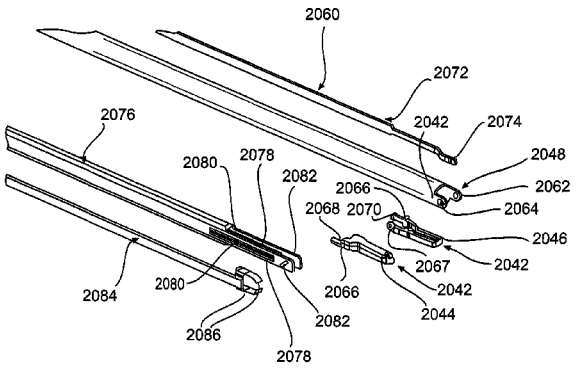
Primary Examiner — Amy R Weisberg

(74) *Attorney, Agent, or Firm* — Baker Hostetler LLP

(57) **ABSTRACT**

An applier for ligation clip is provided. The applier includes: an outer tube having mounting bosses; a pair of jaws pivotally connected to the mounting bosses, the jaws having actuating projections; a feed tube located in the outer tube and configured to move axially within the outer tube, the feed tube having actuating slots in which the actuating projections are located; a clip lock arm located in the outer tube and configured to move axially within the outer tube; and a clip advance arm located in the outer tube and configured to move axially within the outer tube, the clip advance arm having flexible pinchers at one end of the clip advance arm. A method of applying a ligation clip is also disclosed.

19 Claims, 115 Drawing Sheets



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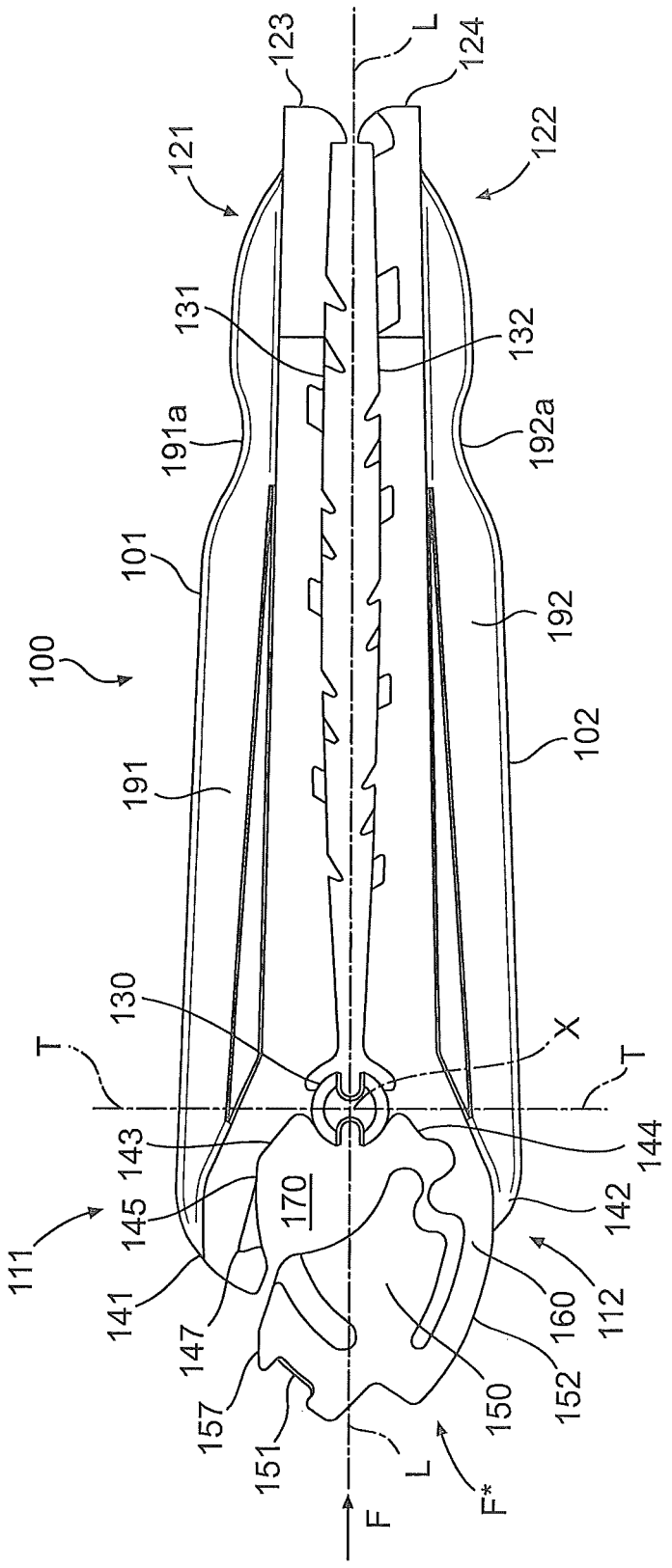
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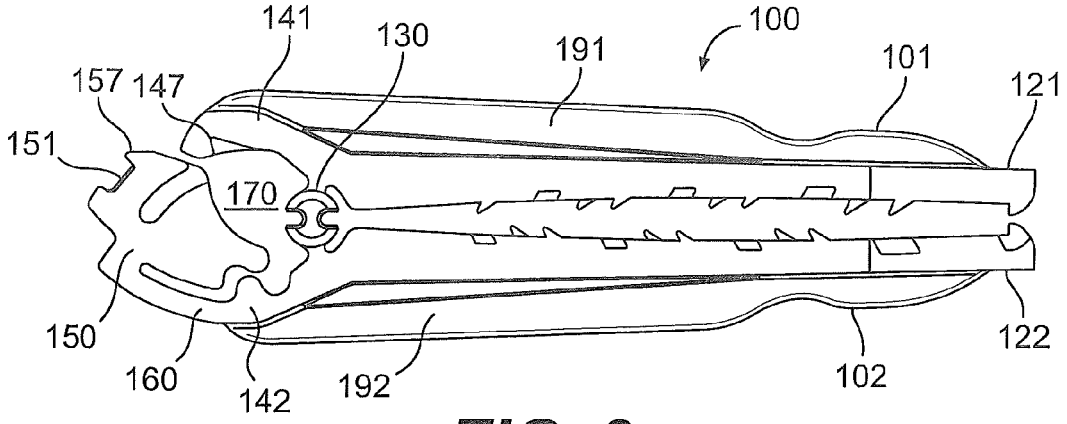
FIG. 1



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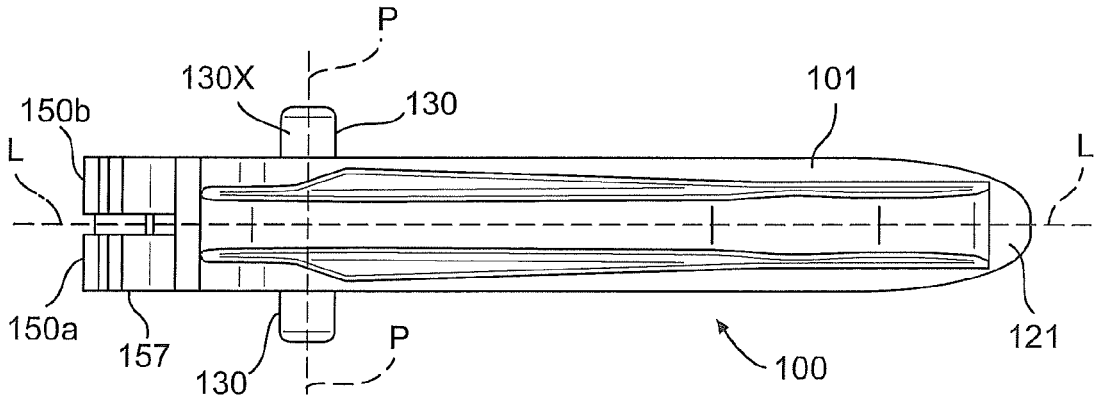

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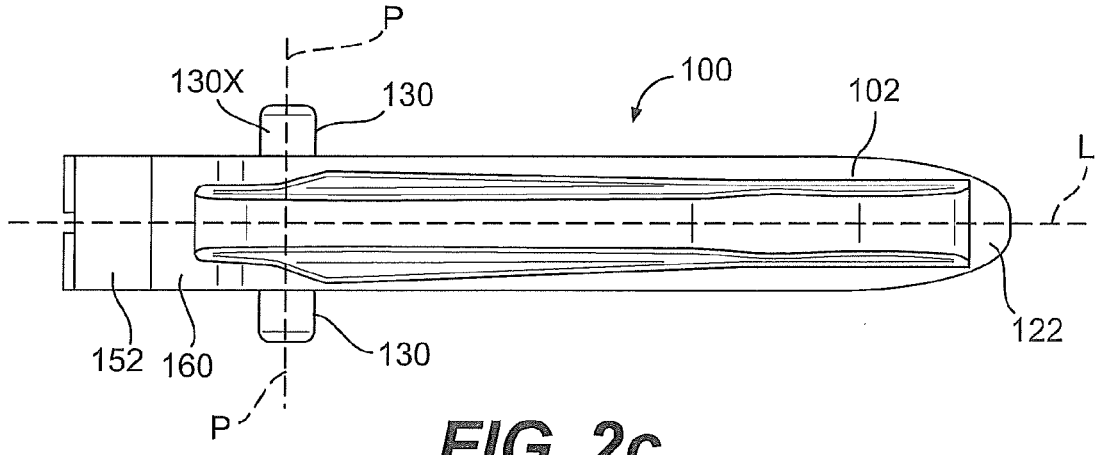
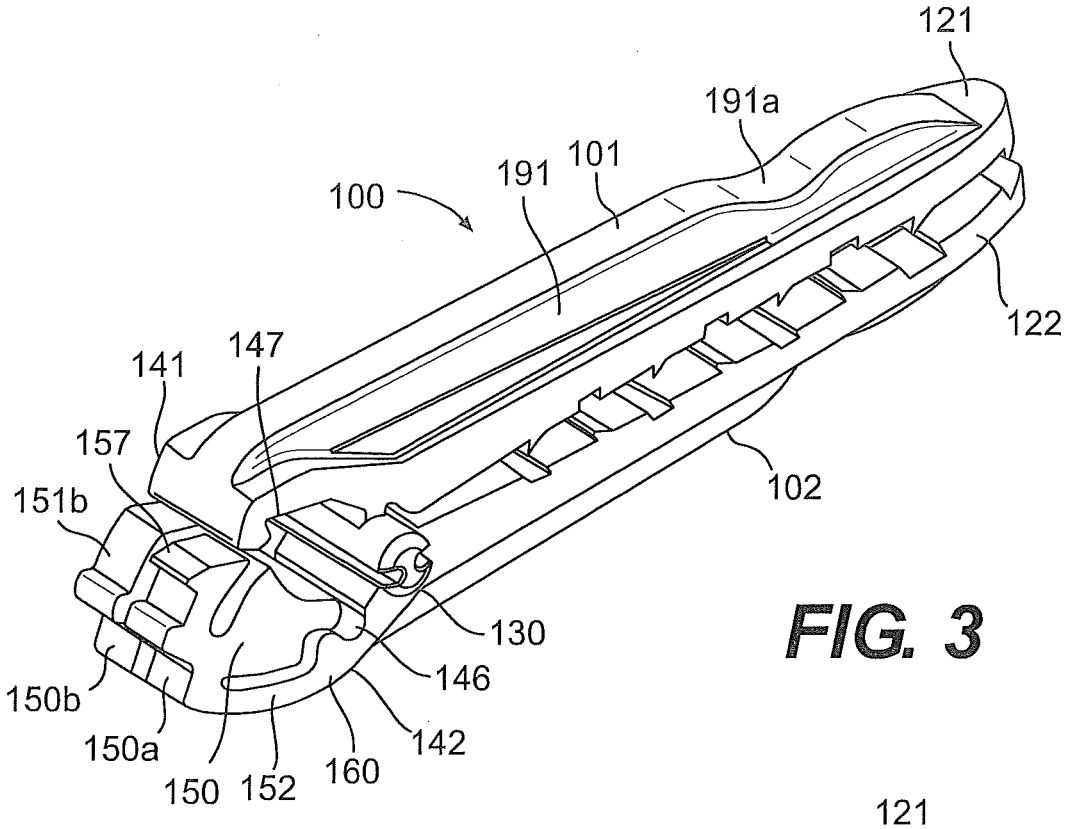


FIG. 2c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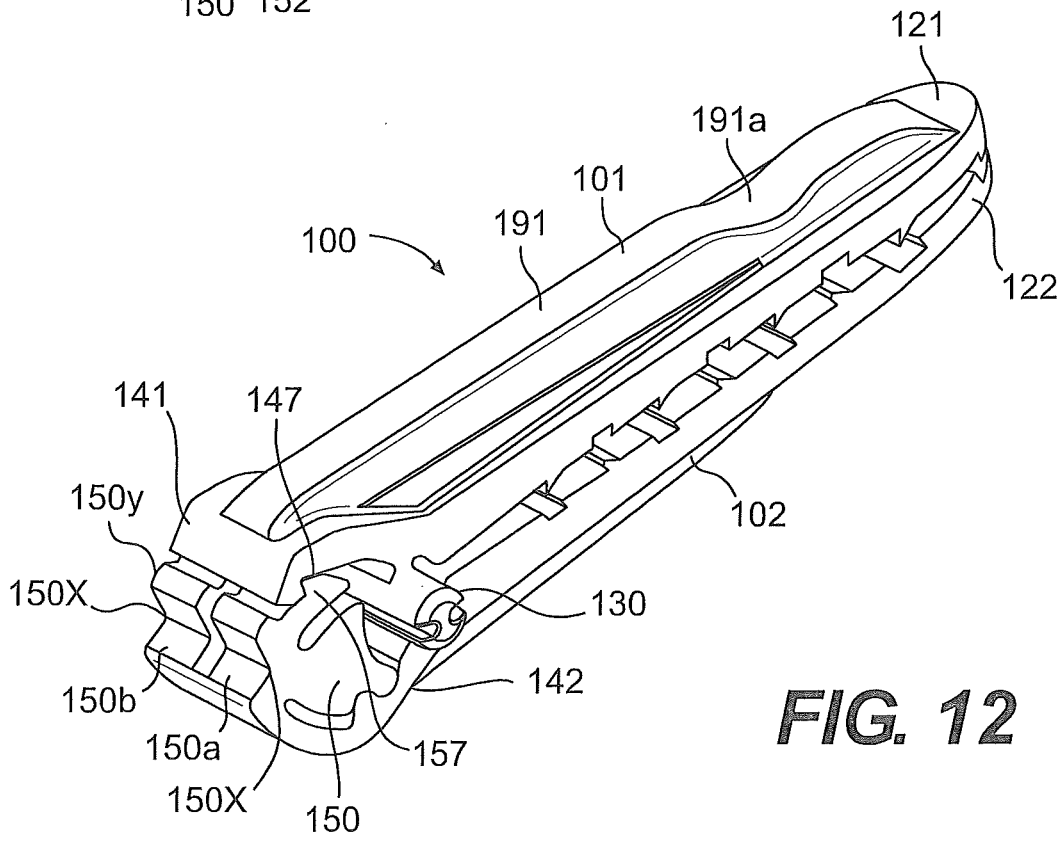
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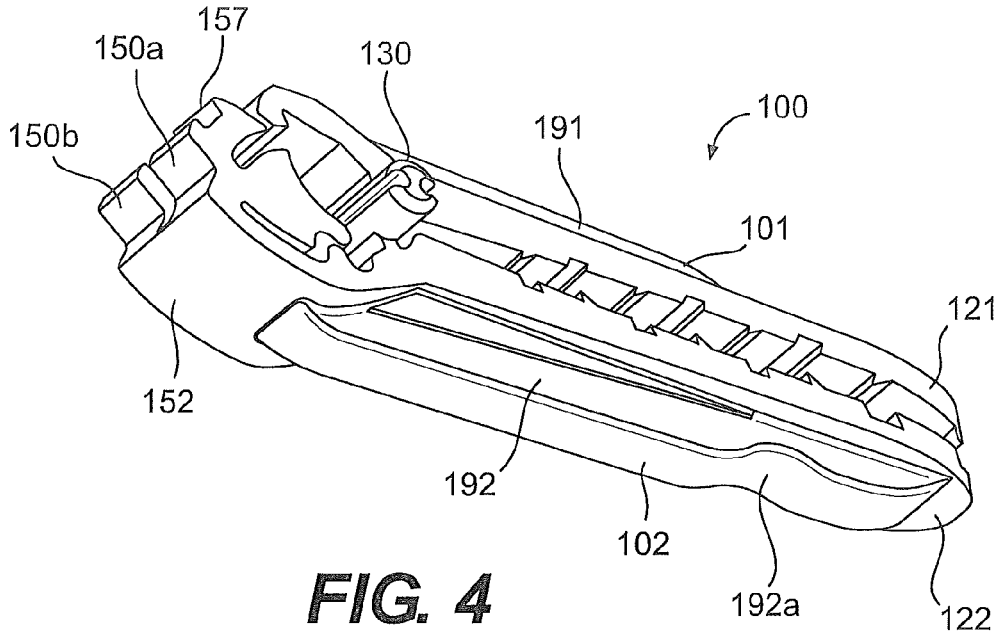
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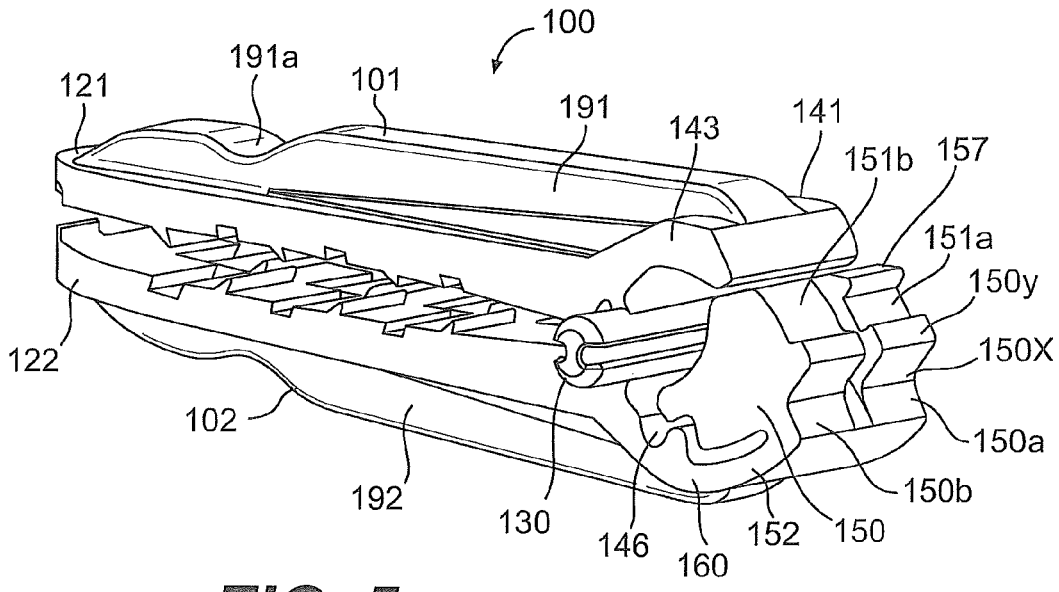
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FIG. 5

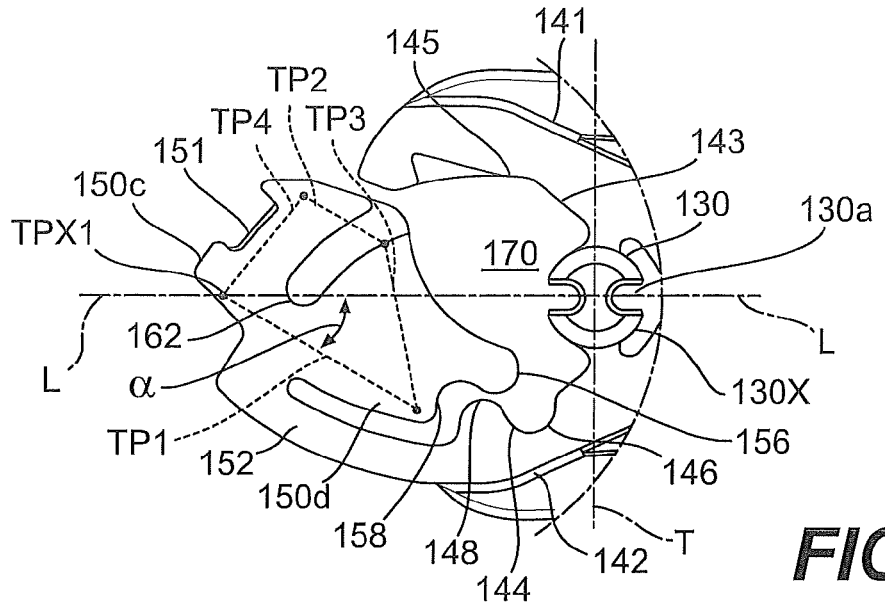


FIG. 6a

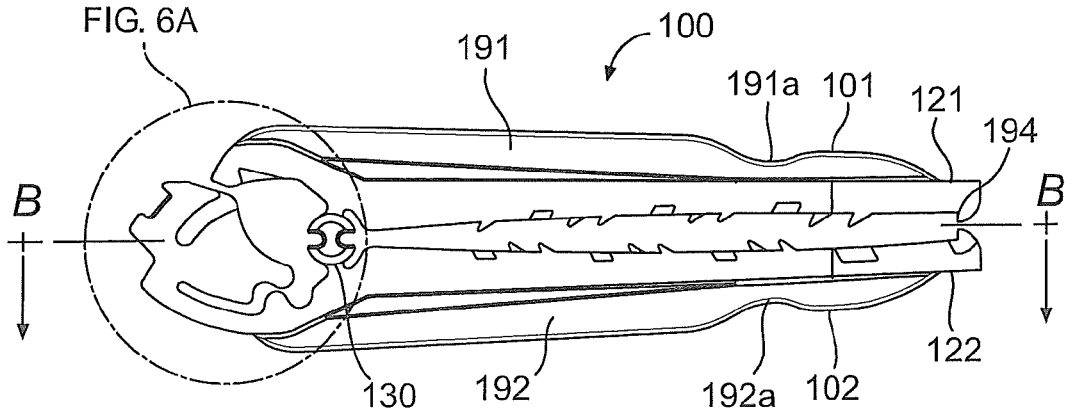


FIG. 6

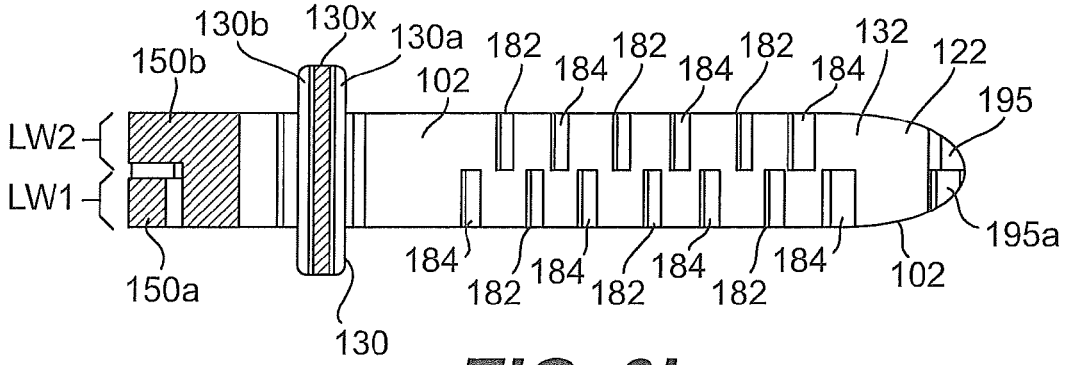


FIG. 6b

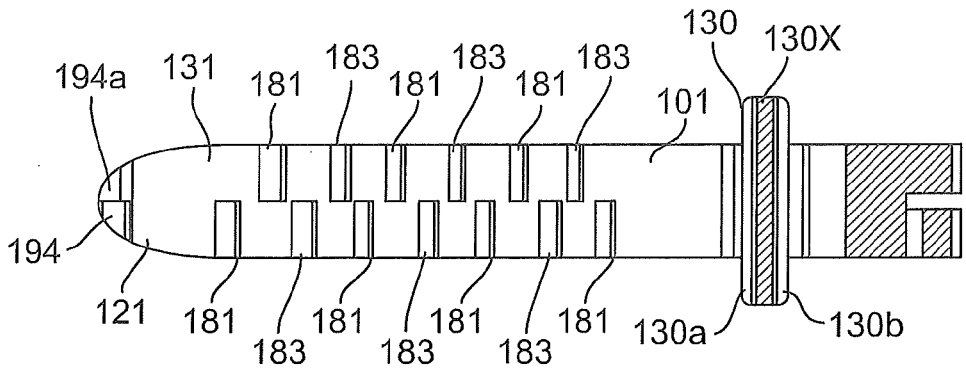
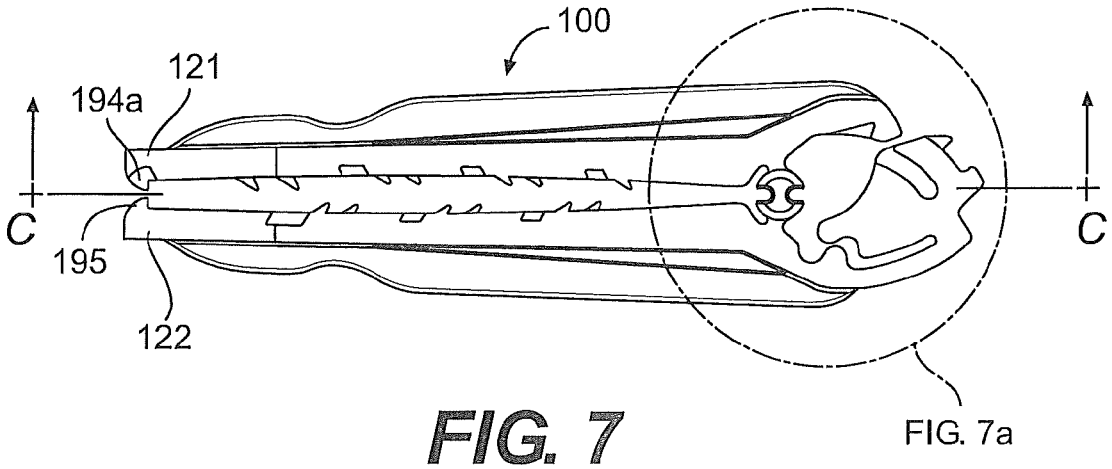


FIG. 7b



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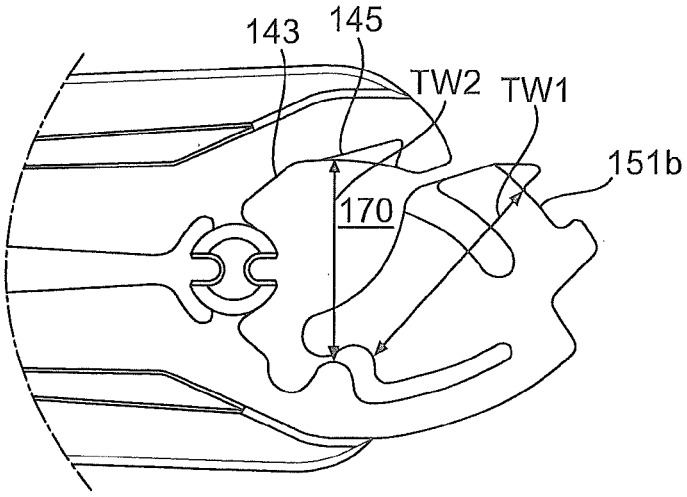

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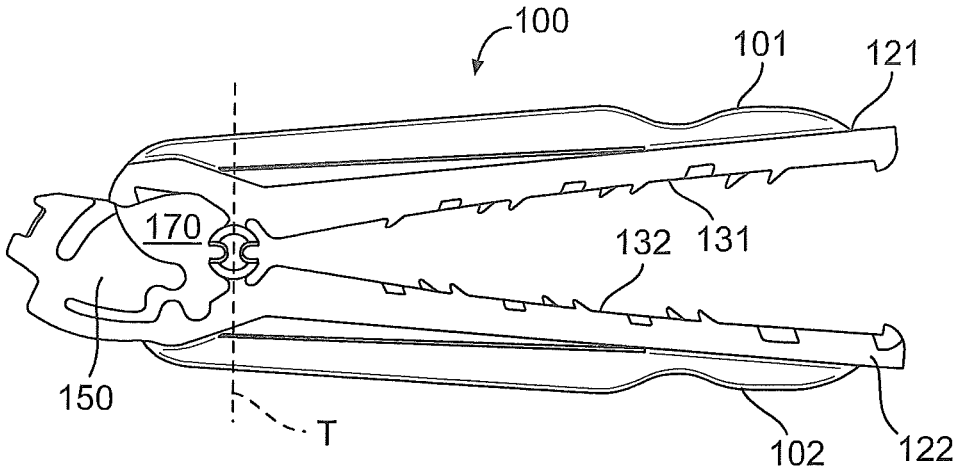

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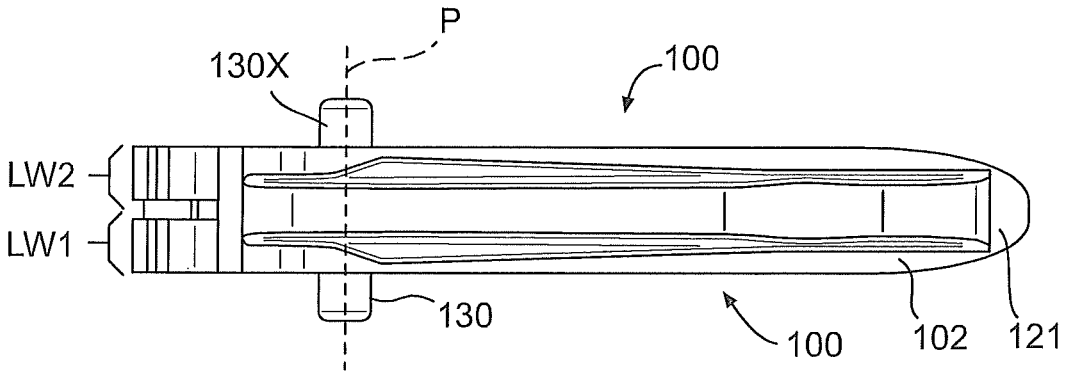

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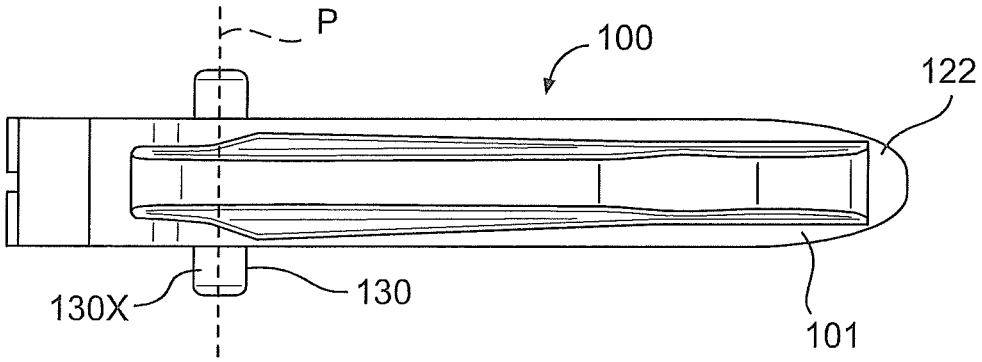

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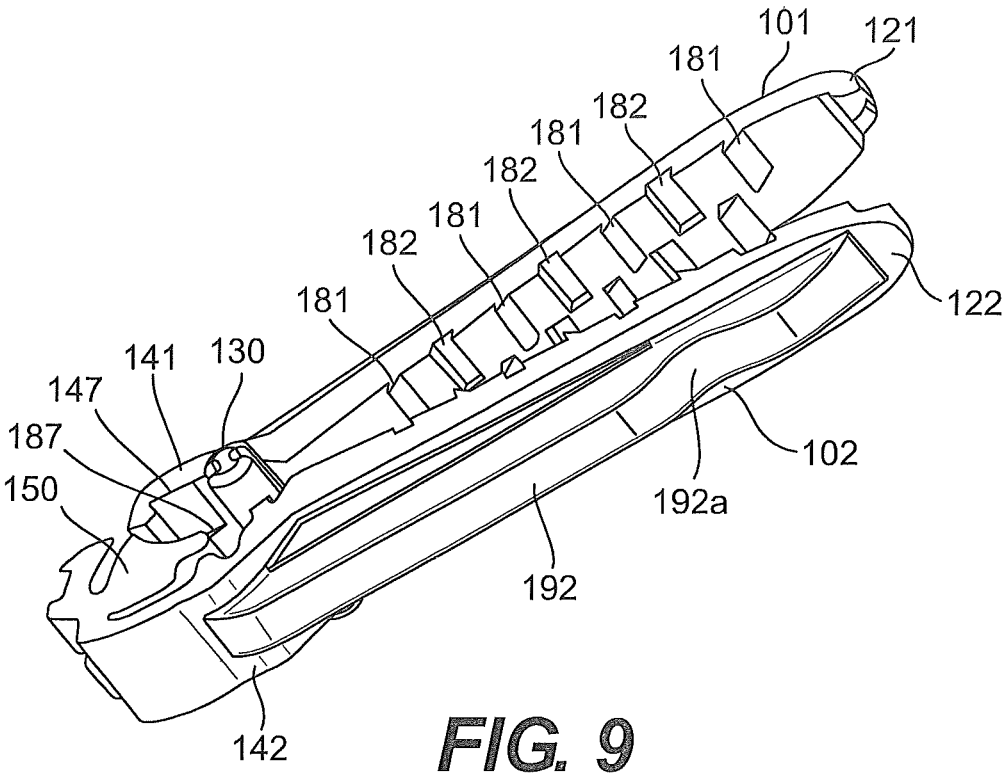
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FIG. 9

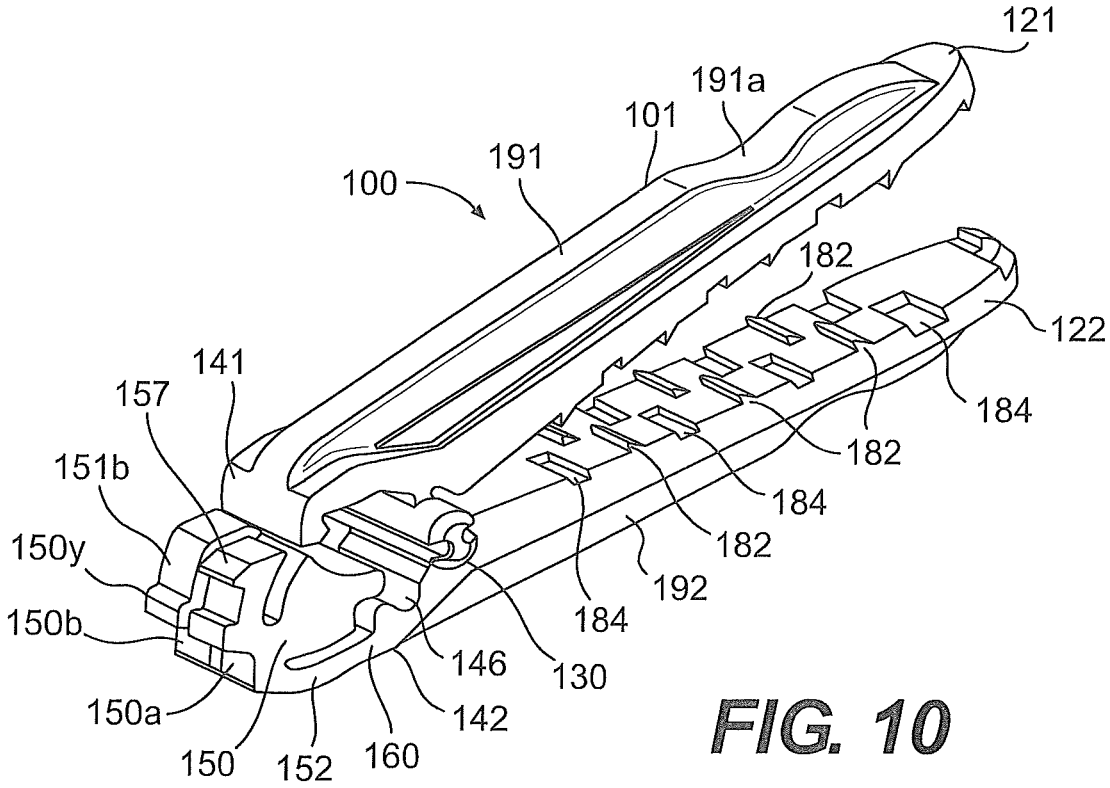
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FIG. 10

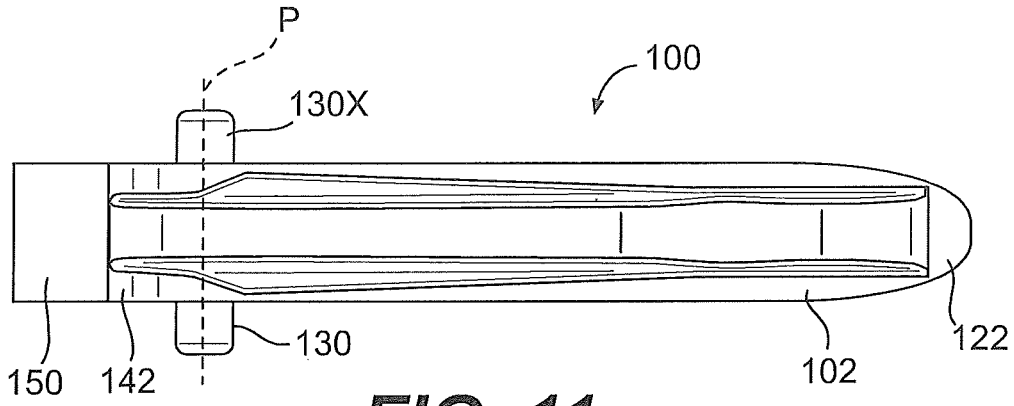

FIG. 11c

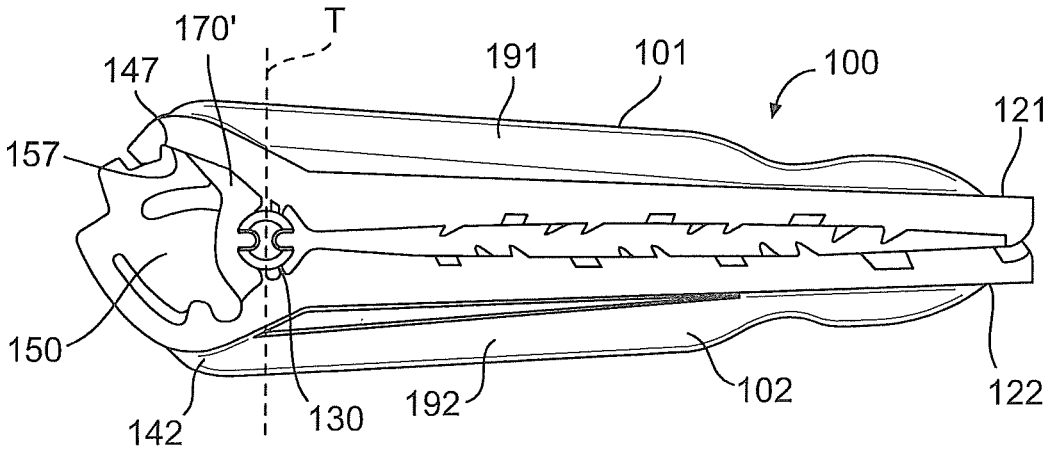

FIG. 11a

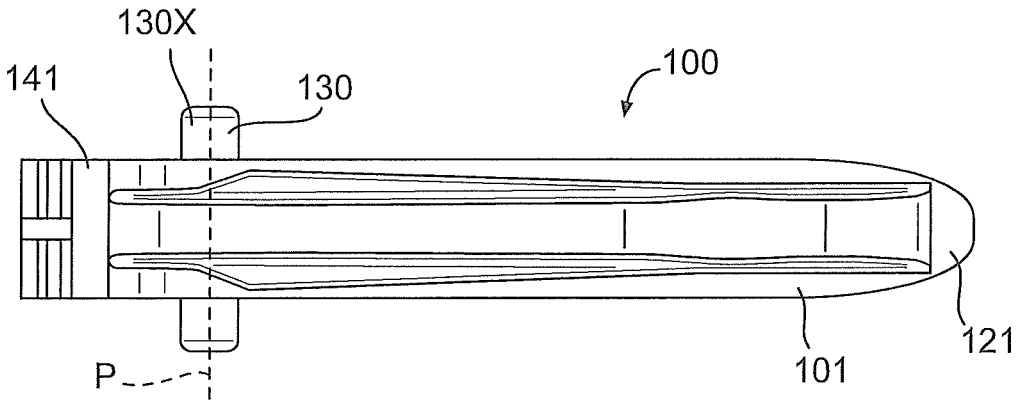

FIG. 11b

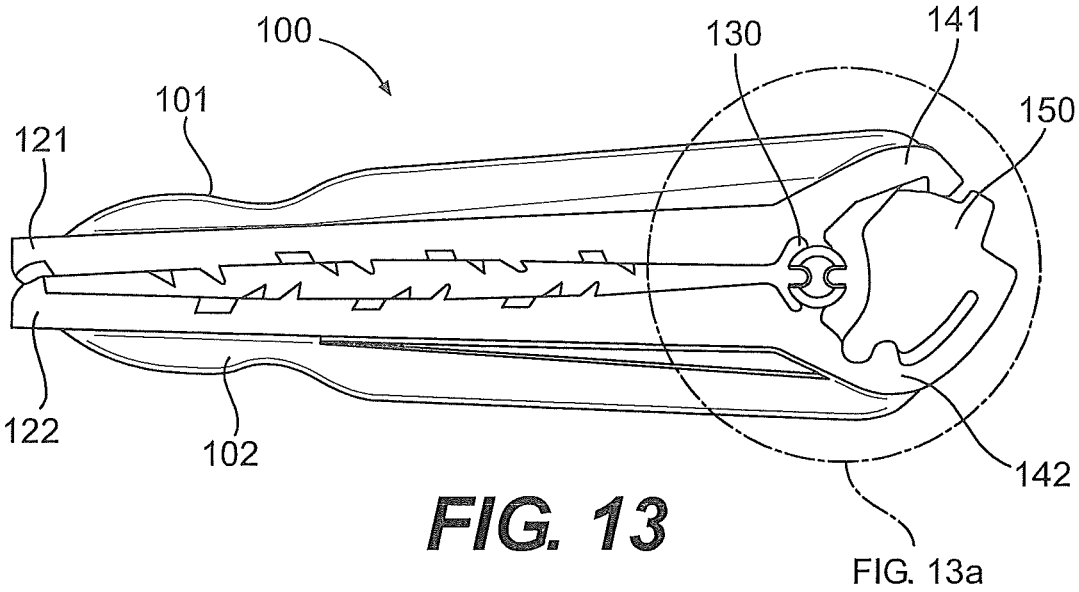

FIG. 13

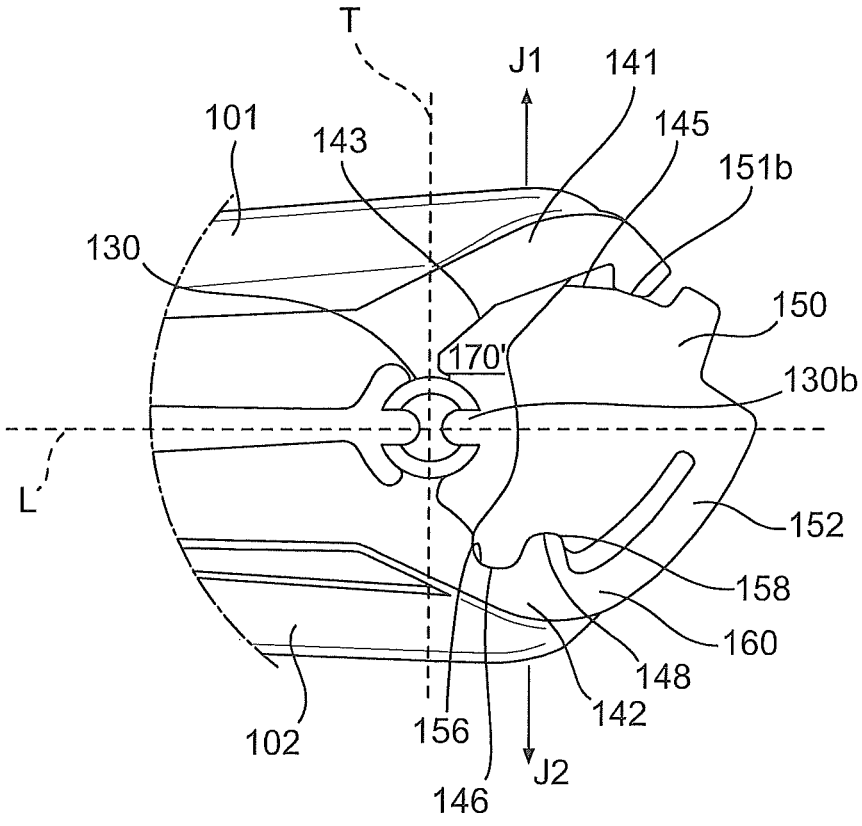

FIG. 13a

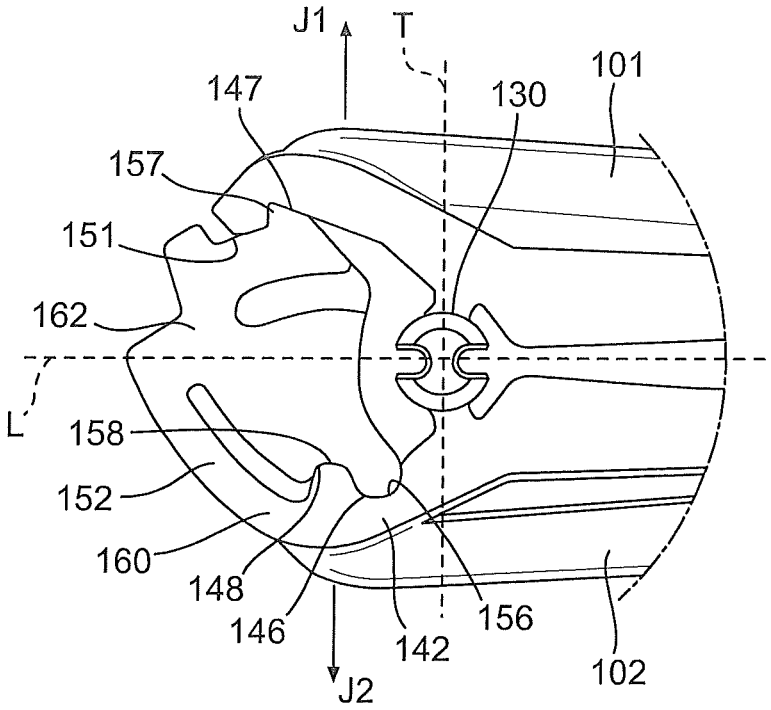

FIG. 14a

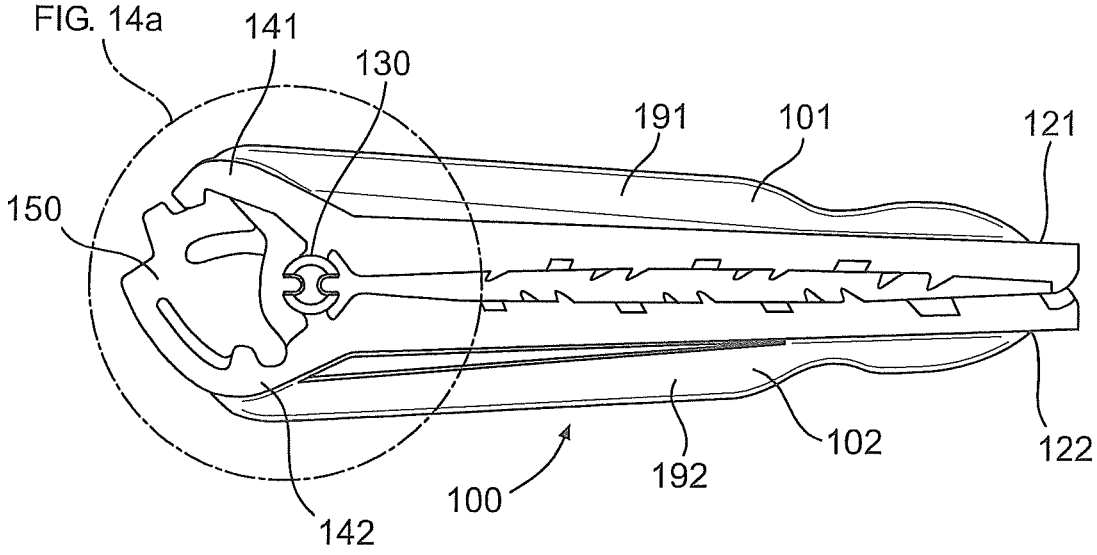

FIG. 14

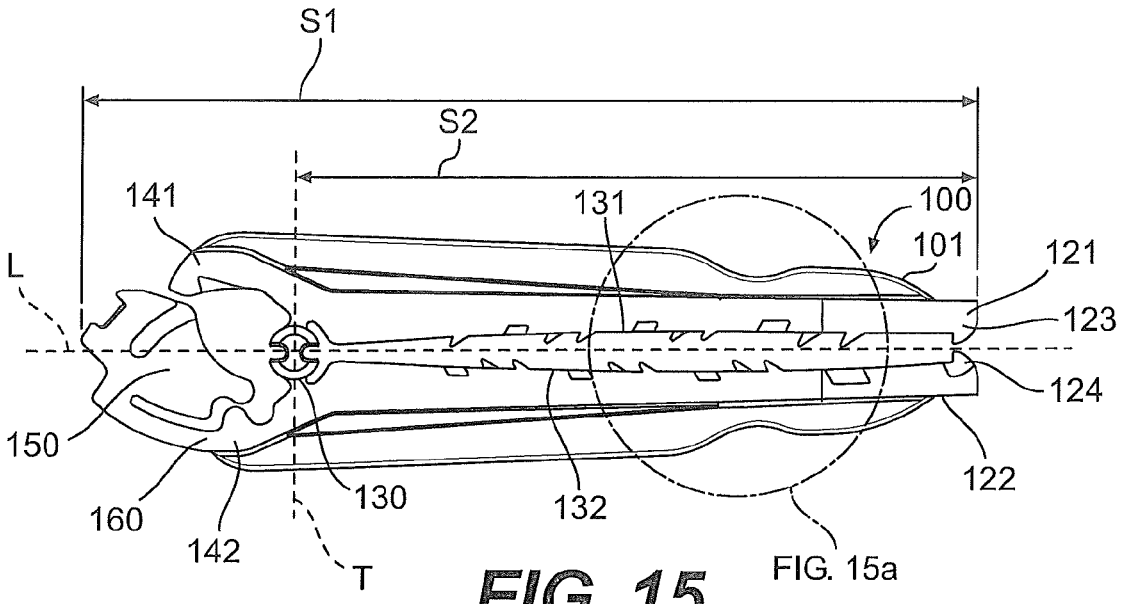

FIG. 15

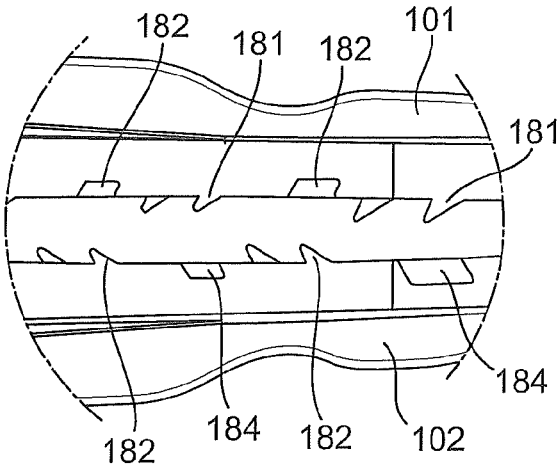

FIG. 15a

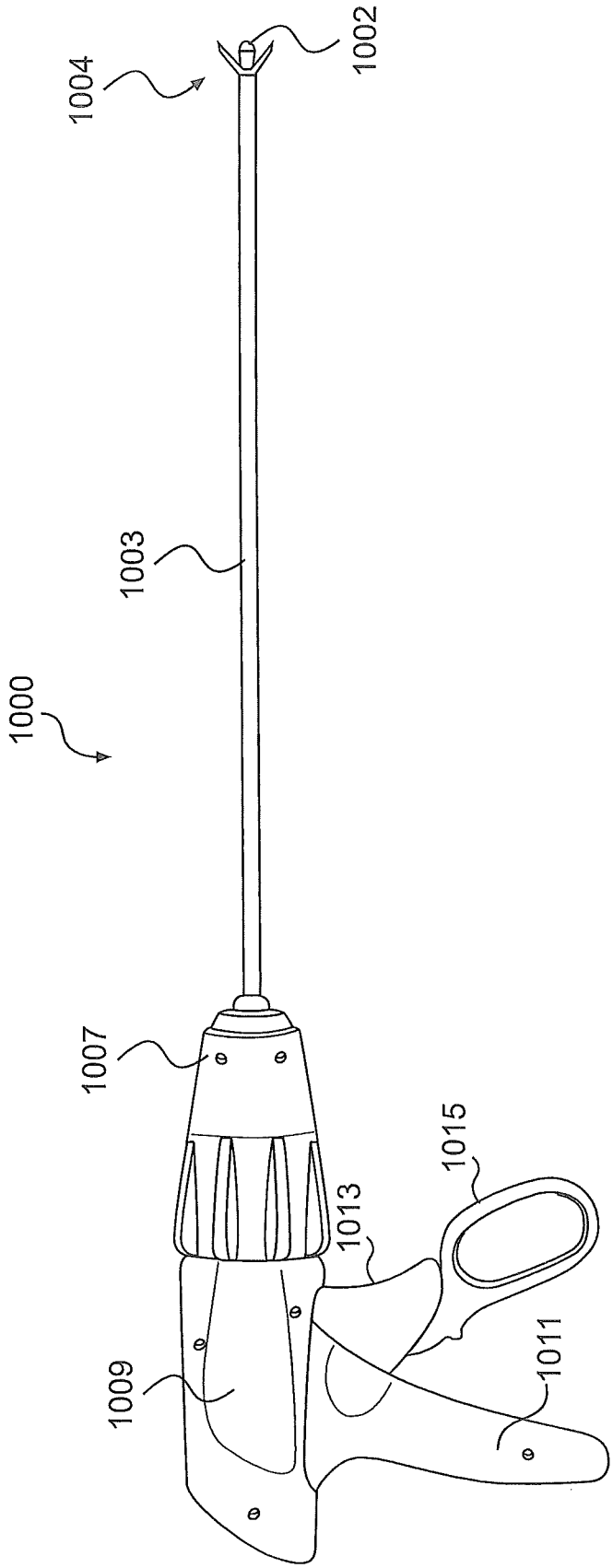

FIG. 16

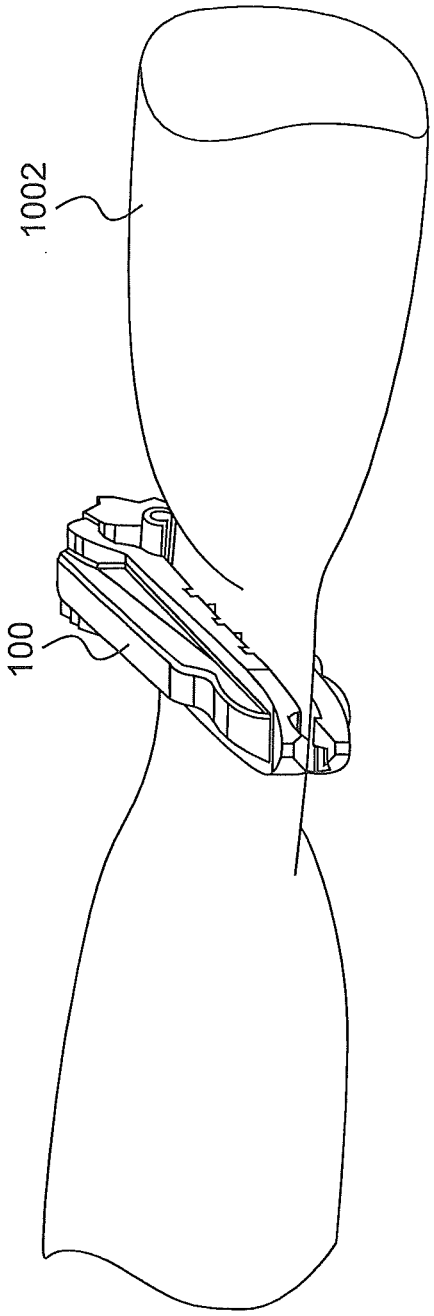

FIG. 17

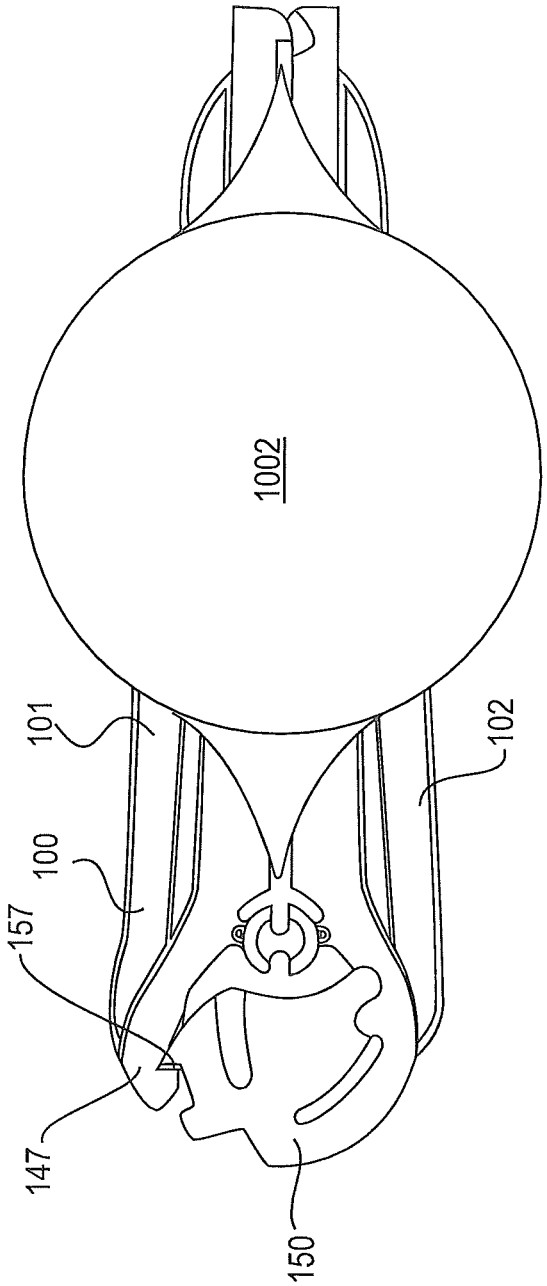

FIG. 18

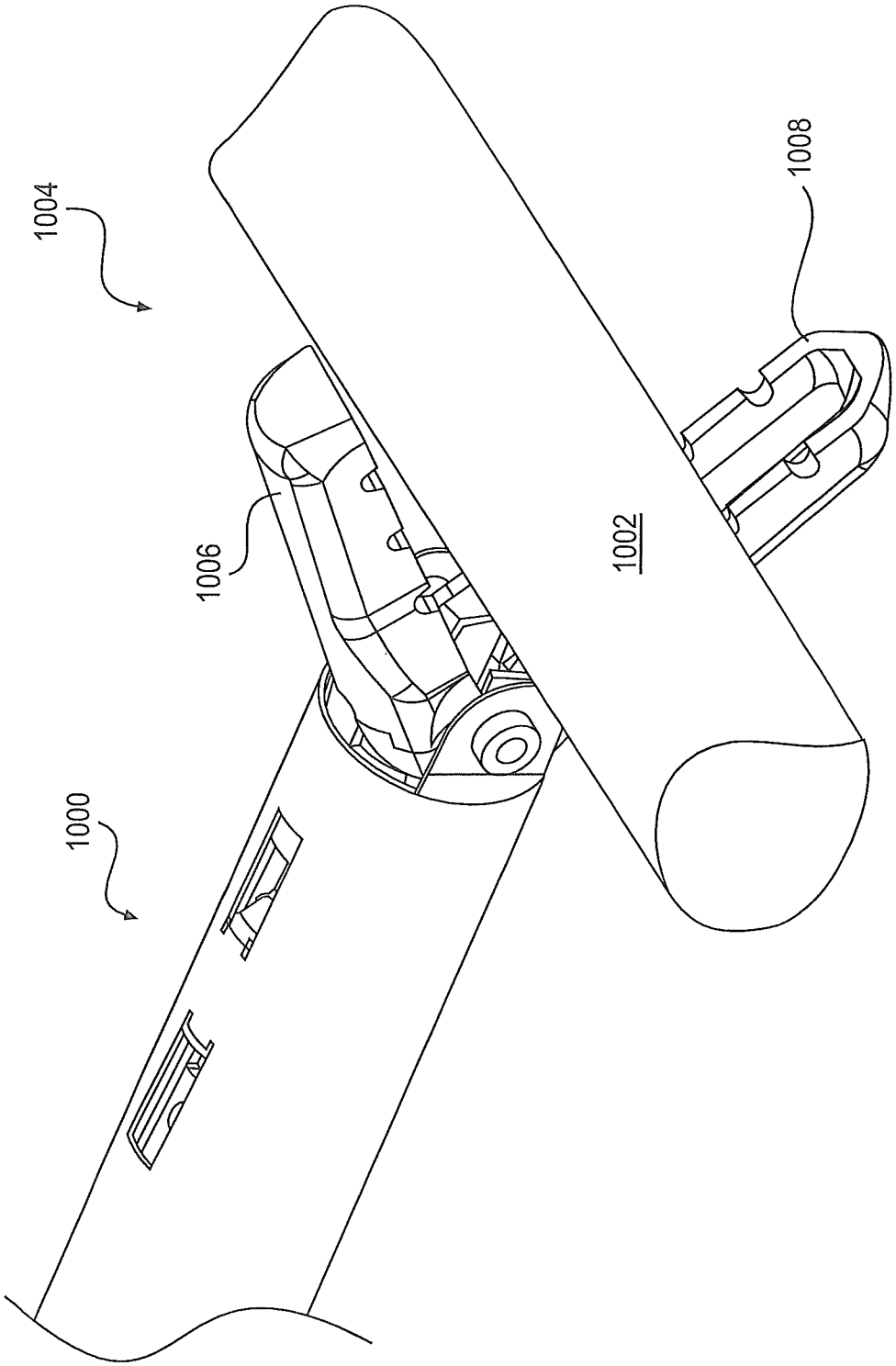

FIG. 19

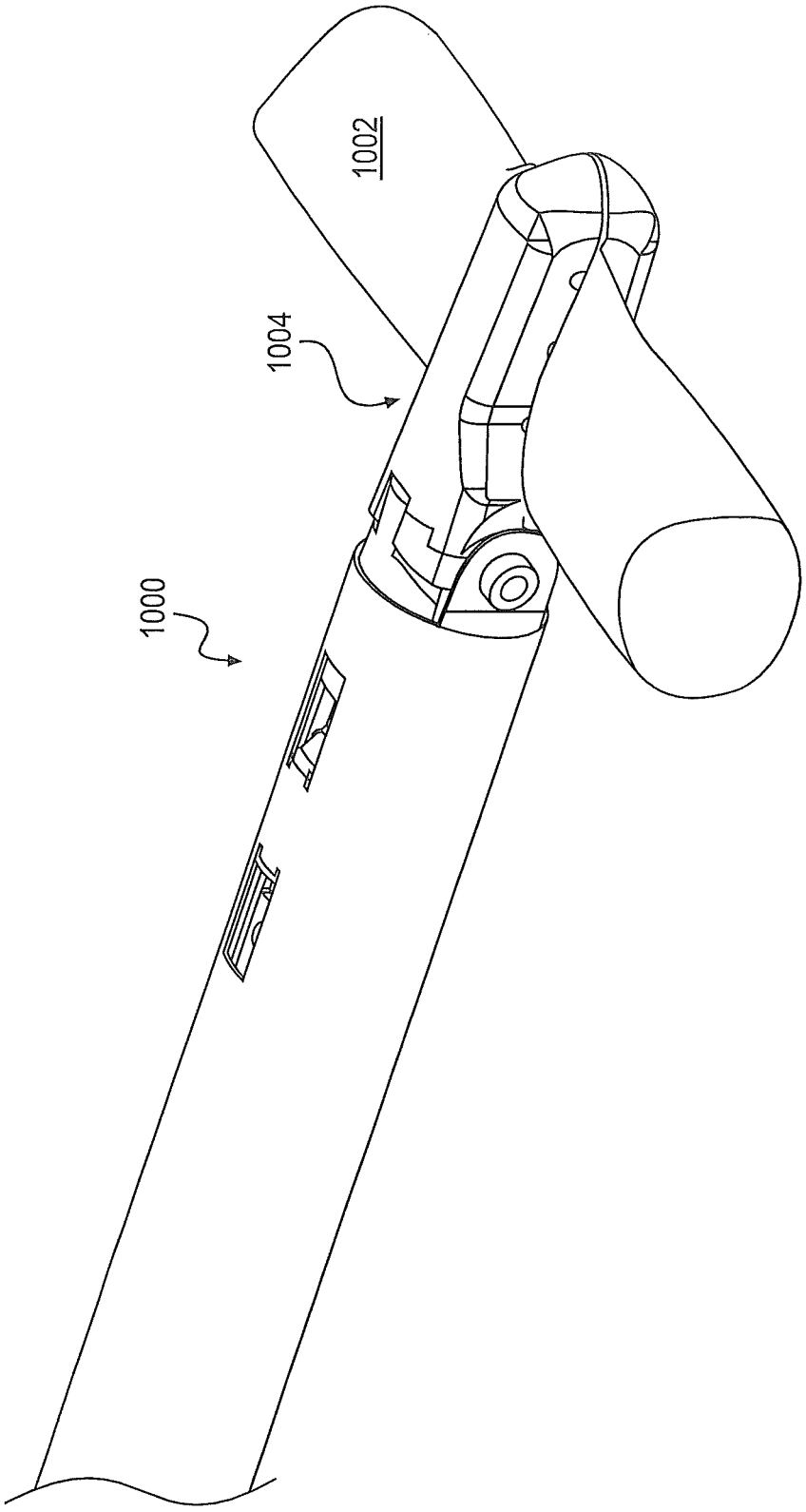

FIG. 20

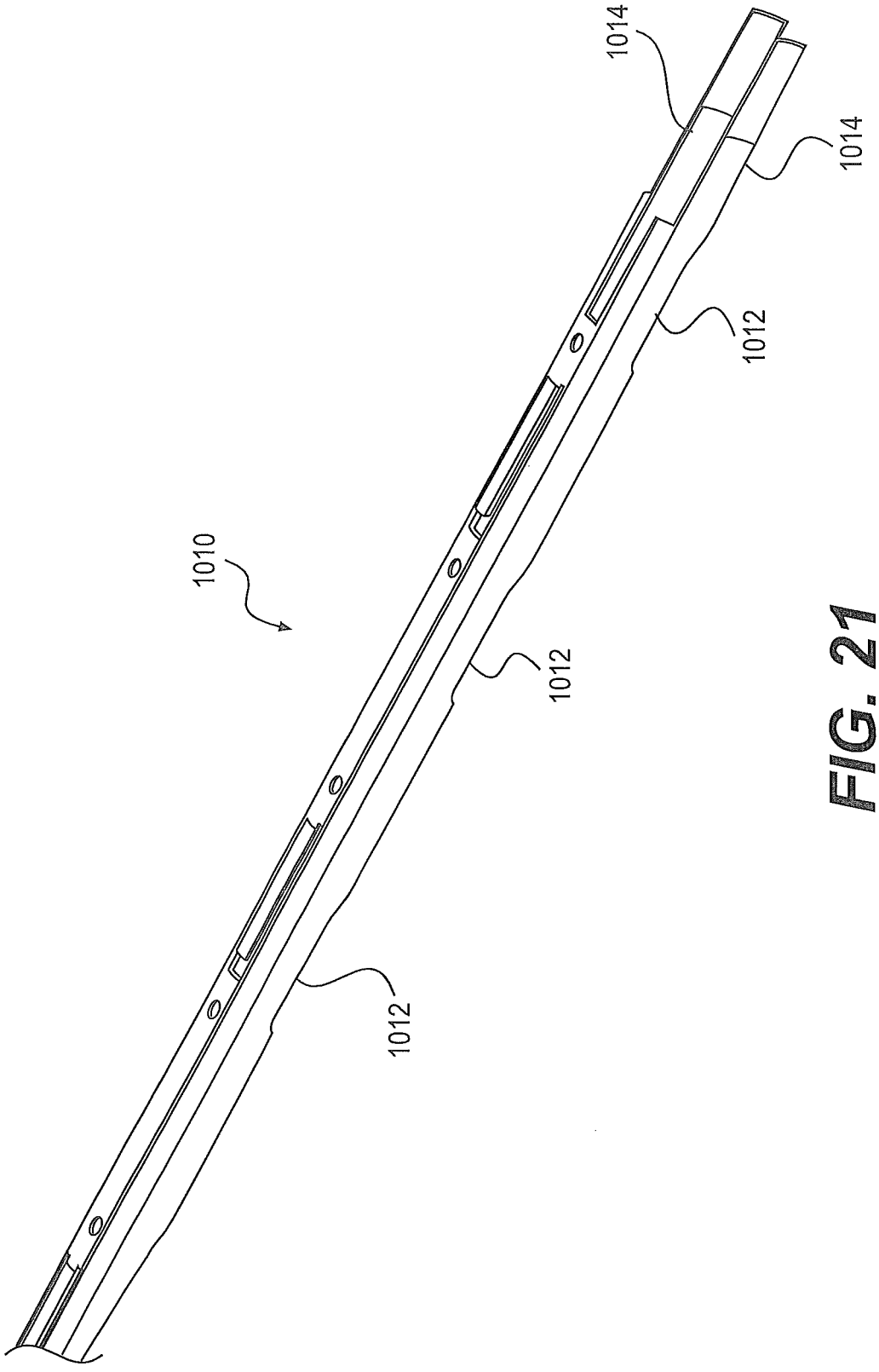

FIG. 21

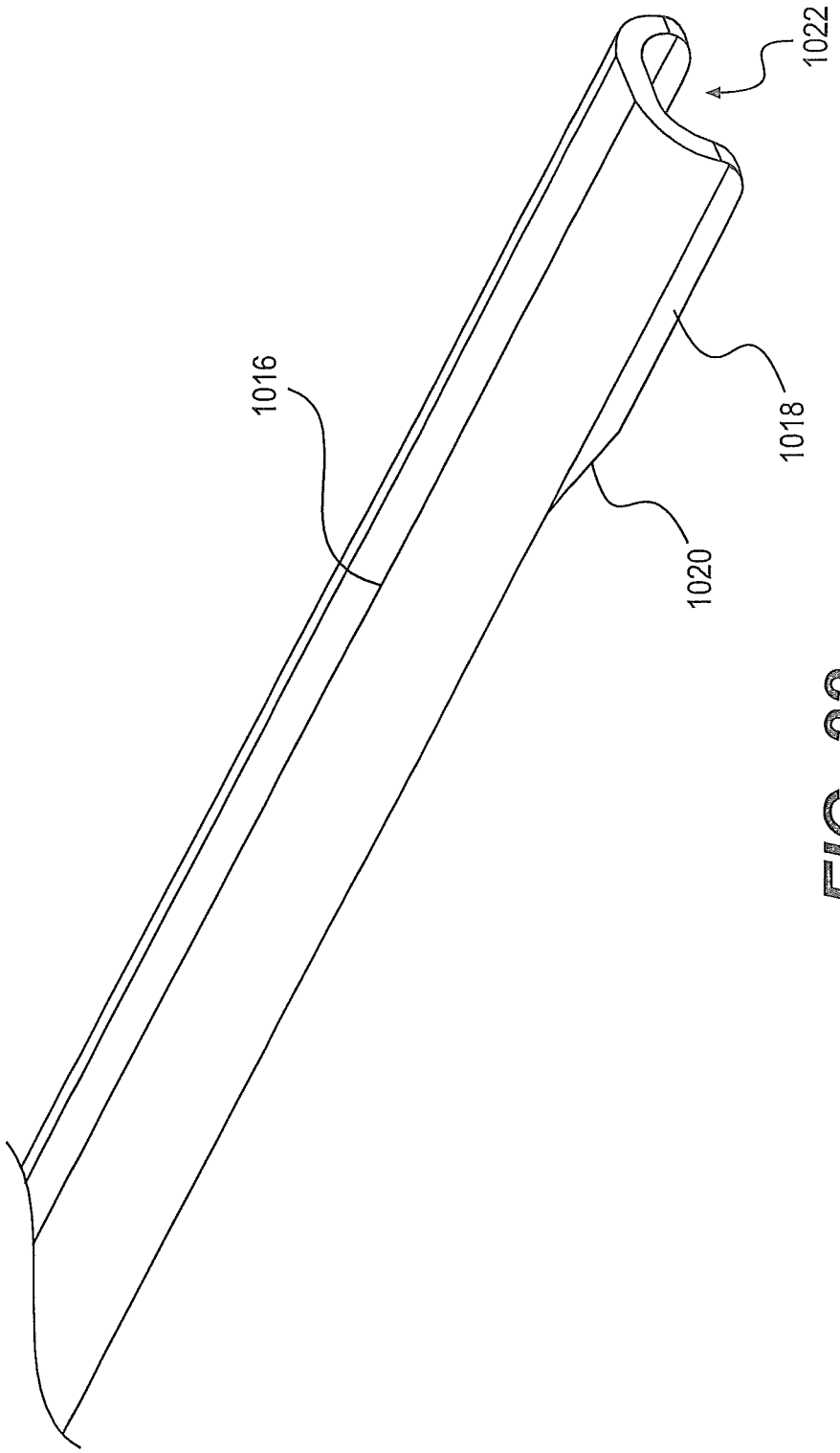

FIG. 22

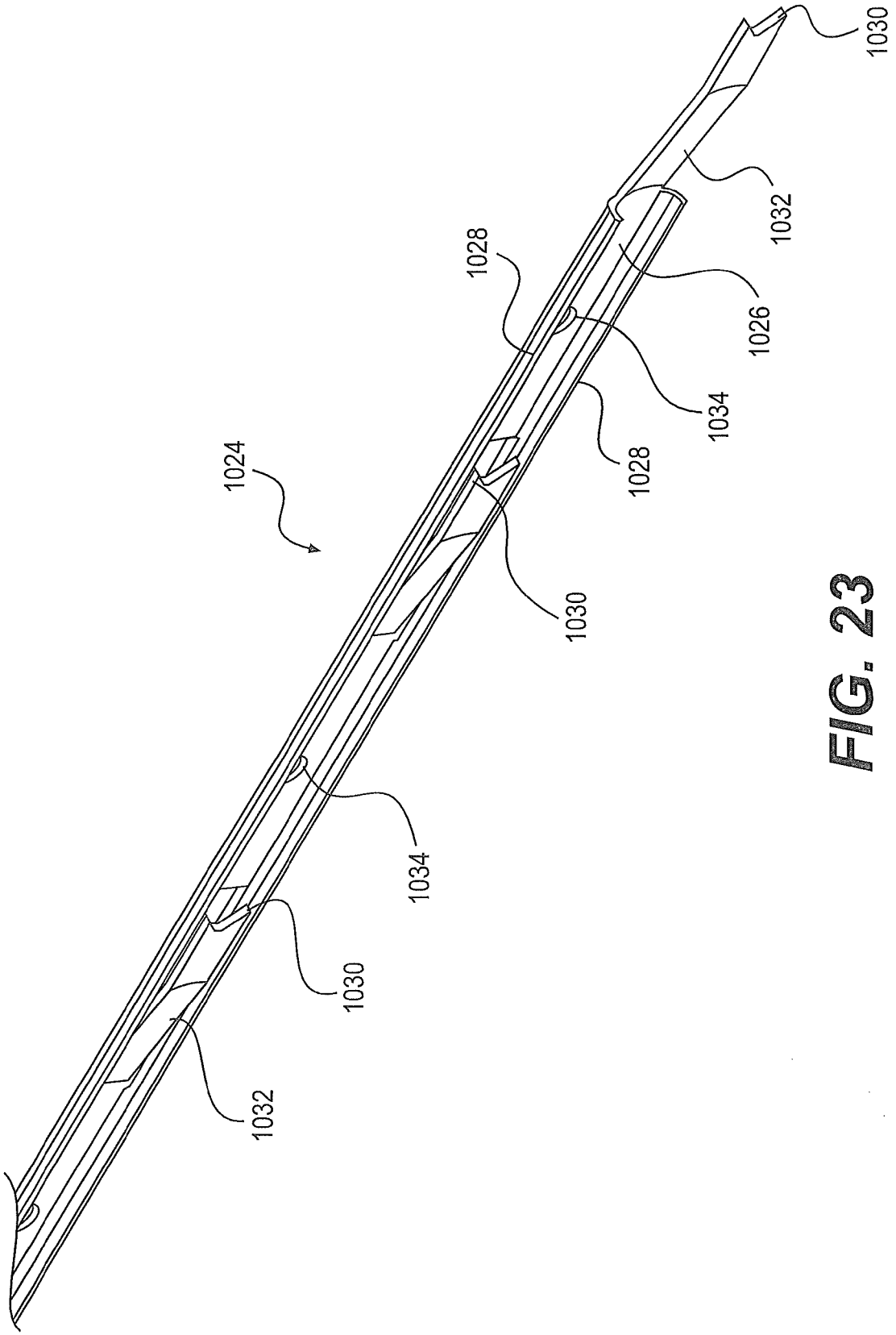

FIG. 23

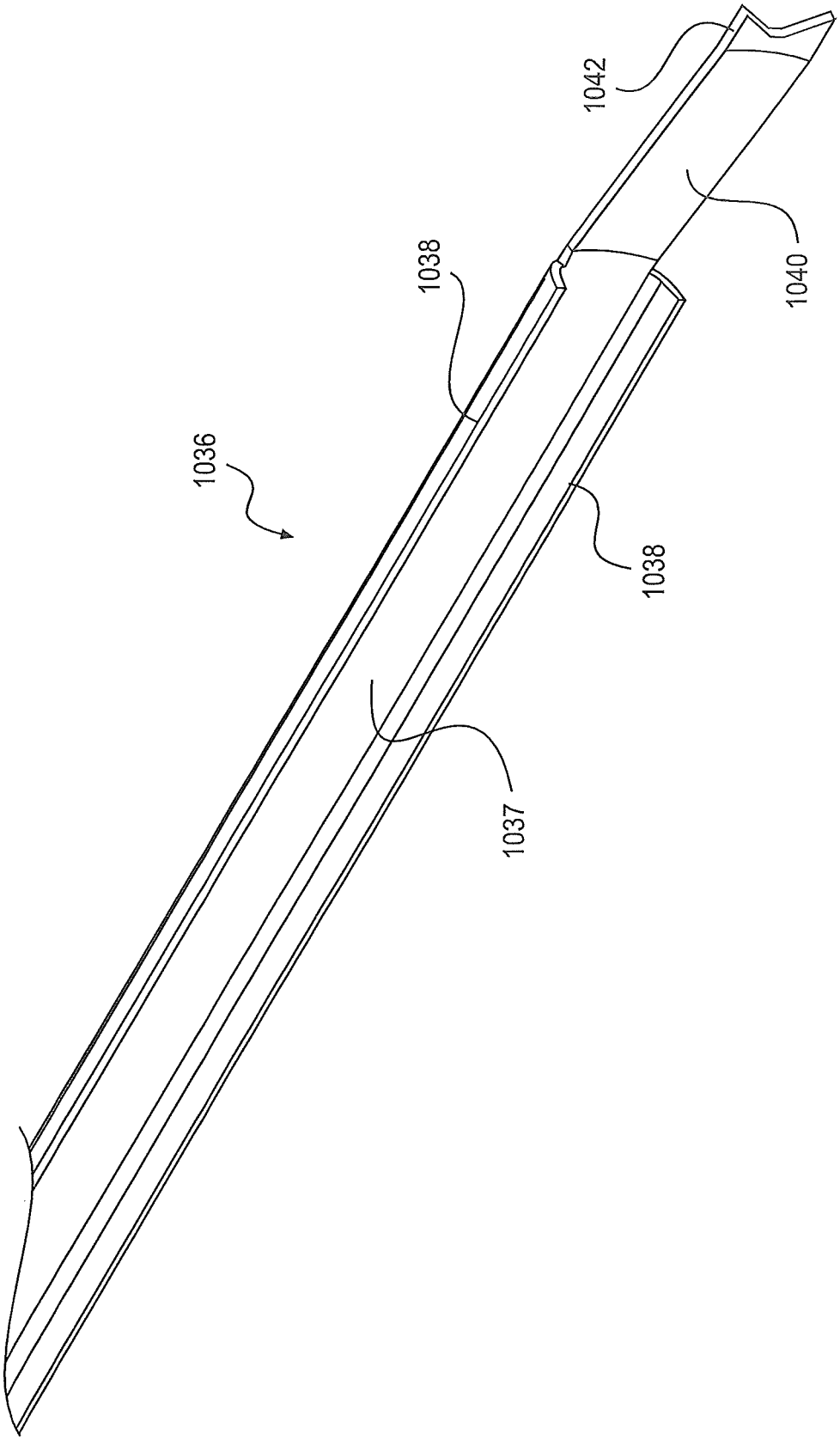

FIG. 24

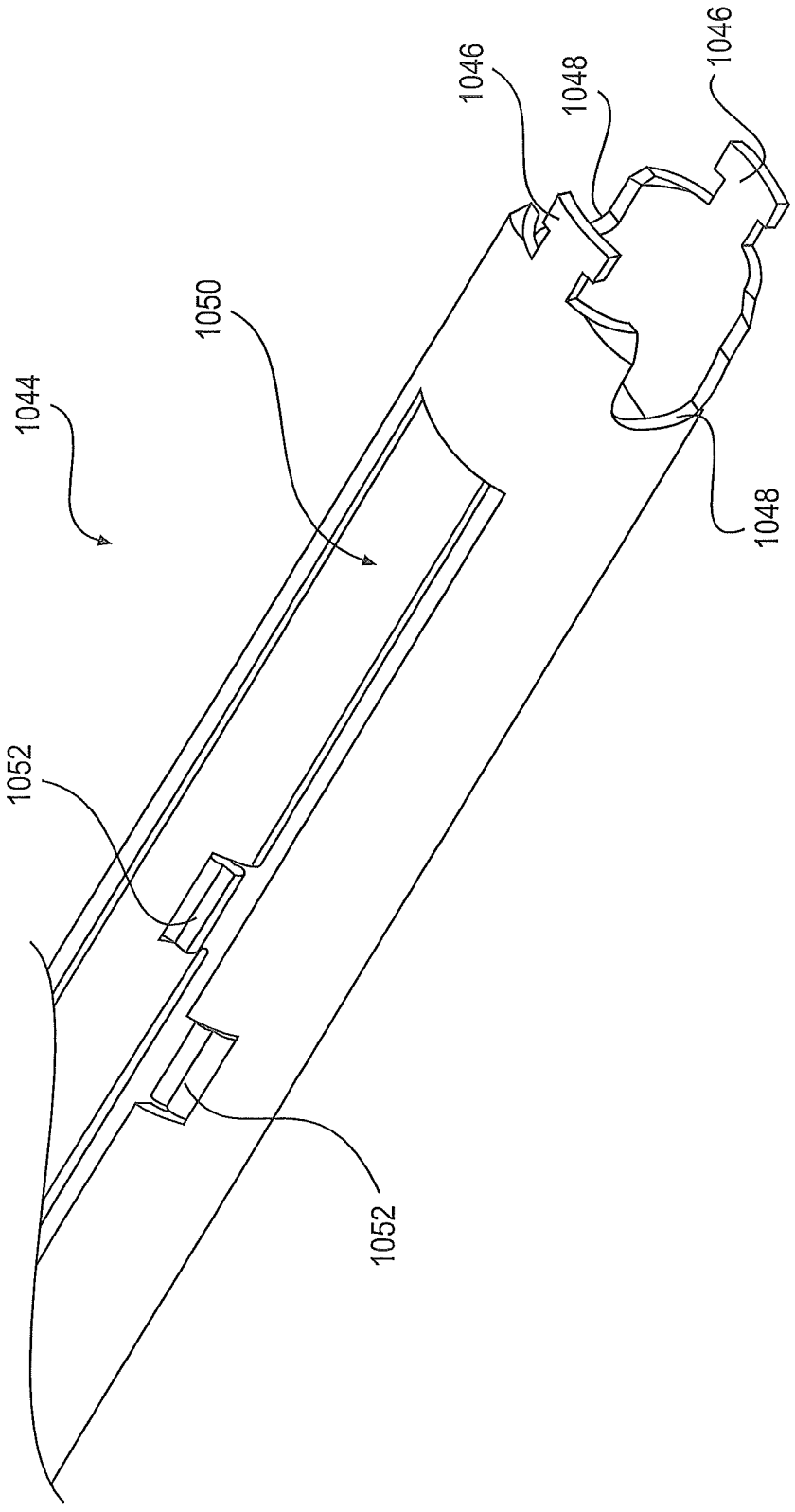

FIG. 25

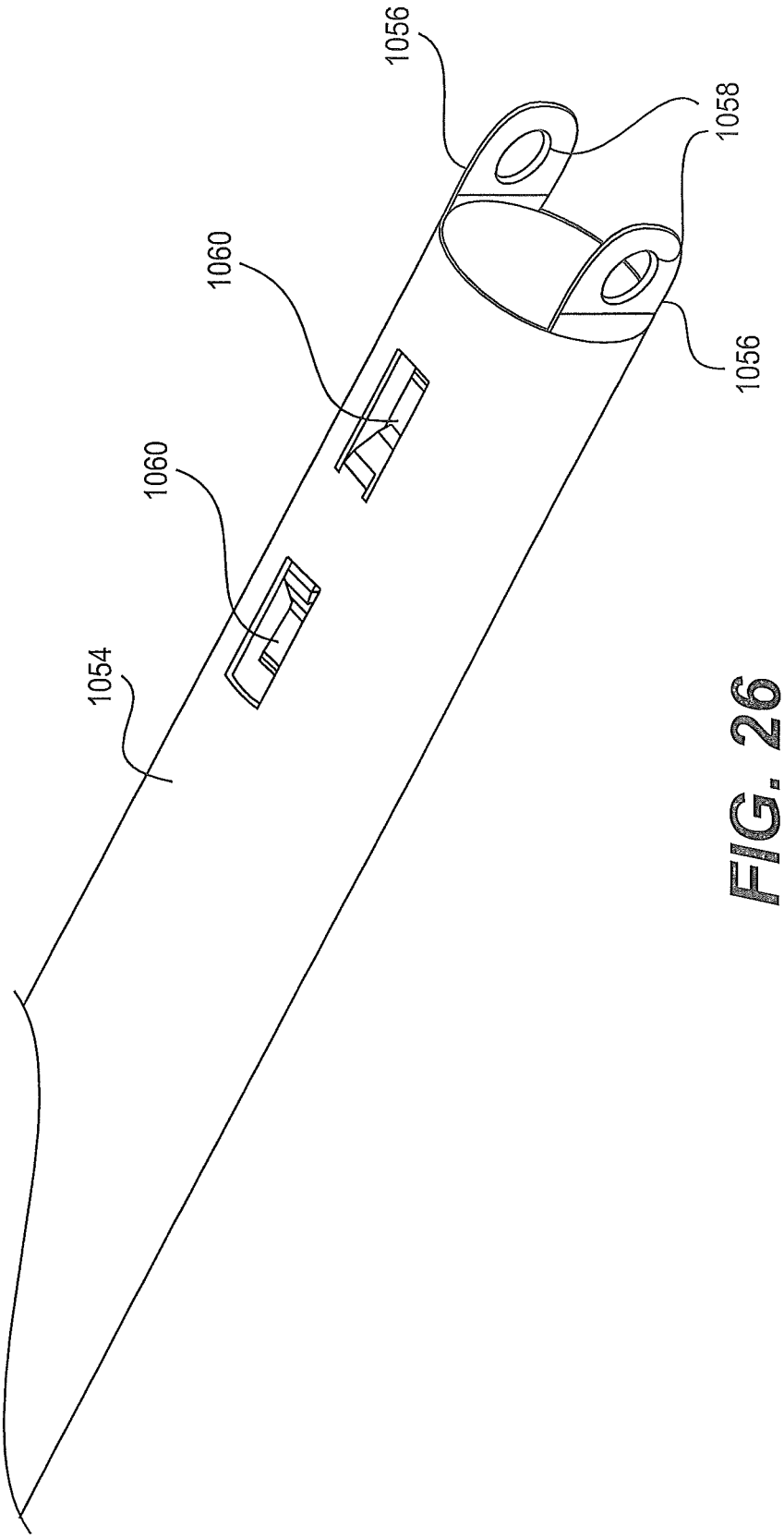

FIG. 26

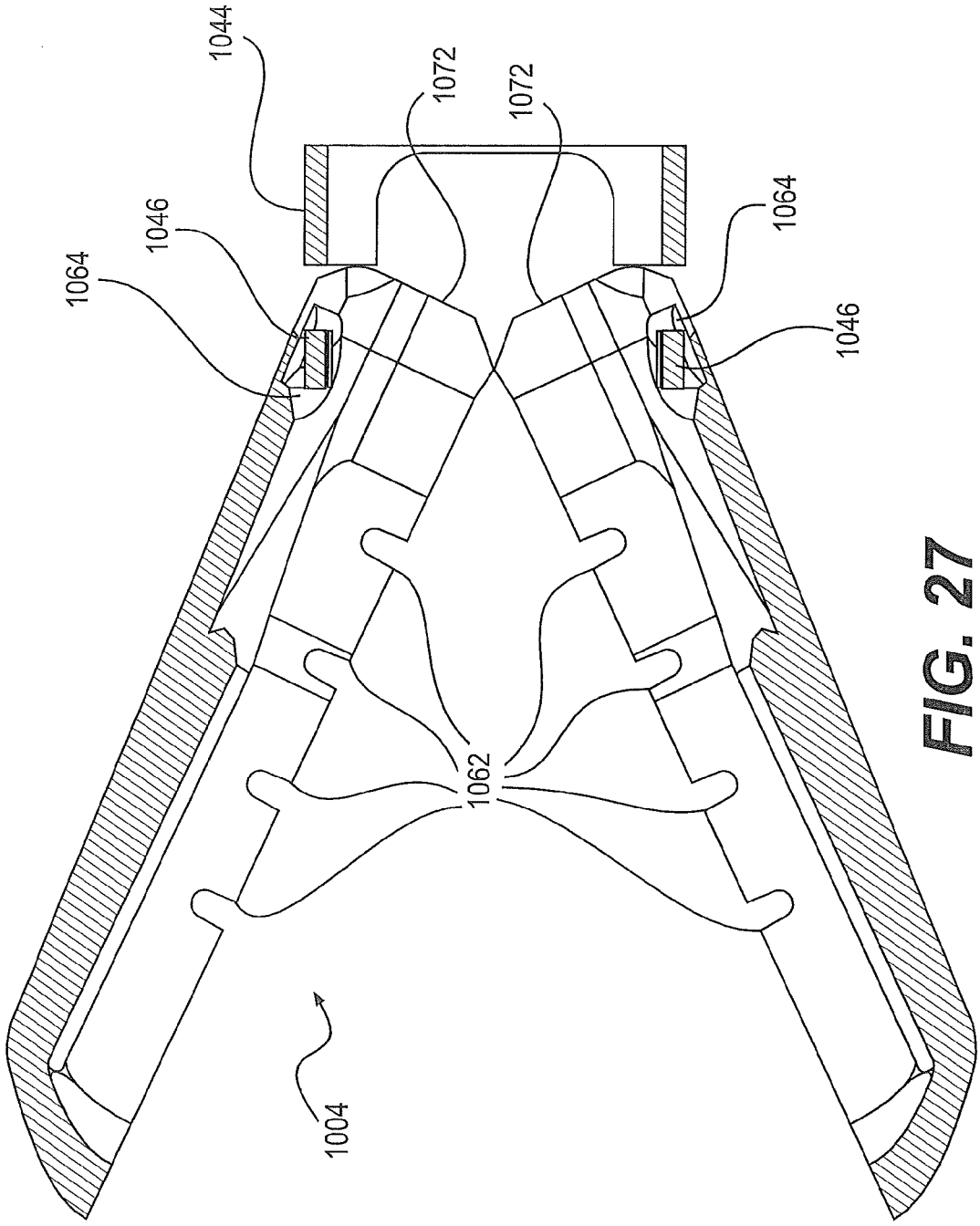

FIG. 27

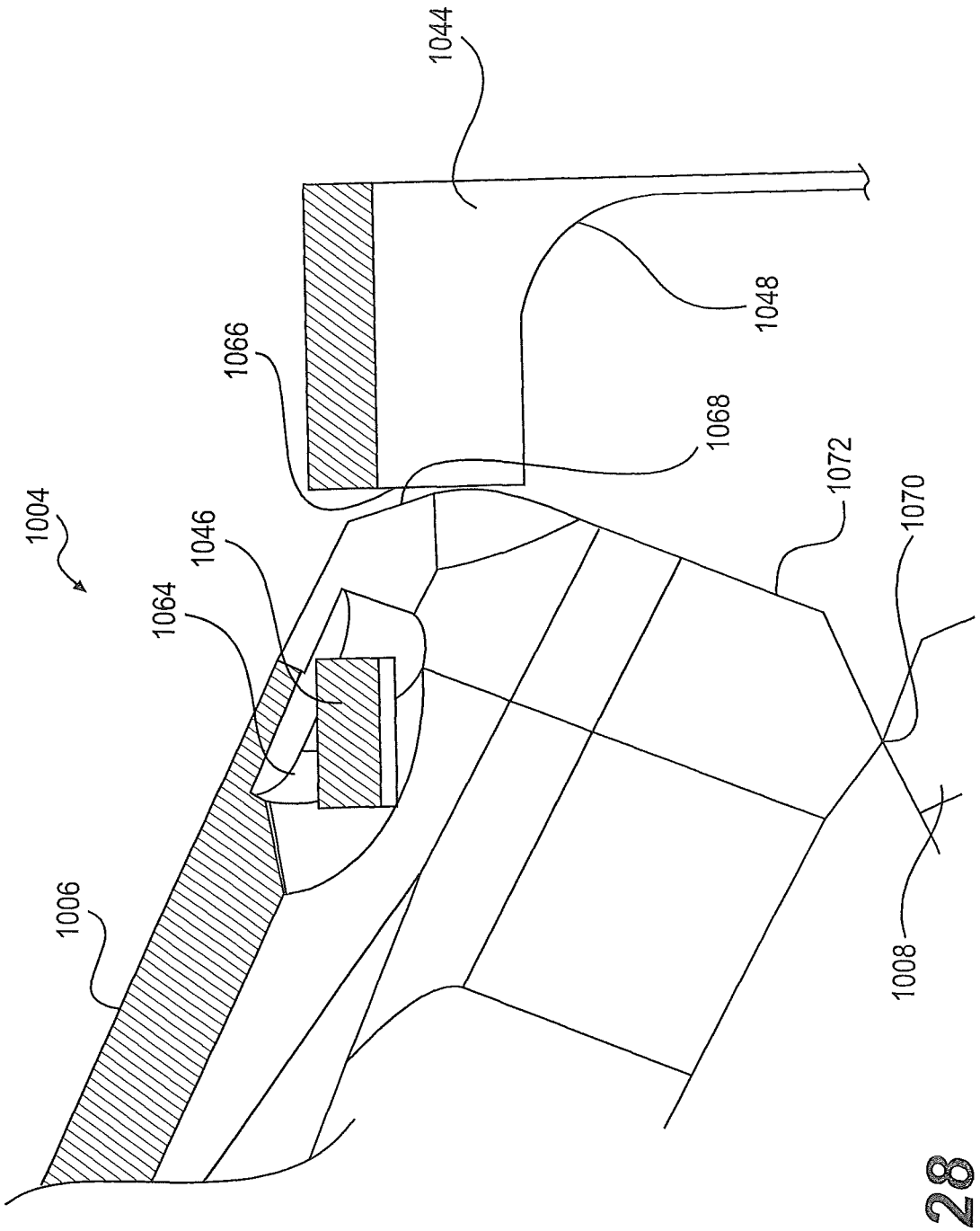

FIG. 28

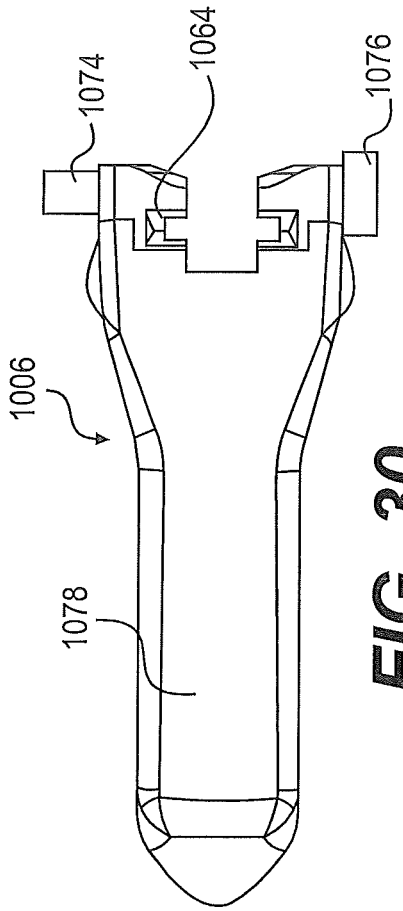

FIG. 30

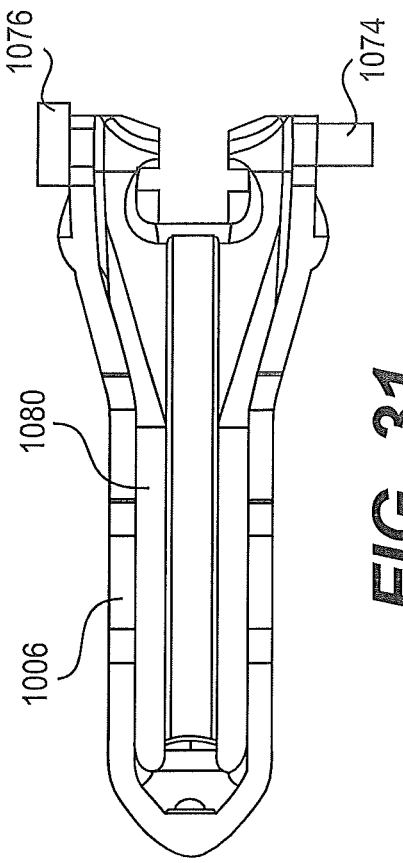

FIG. 31

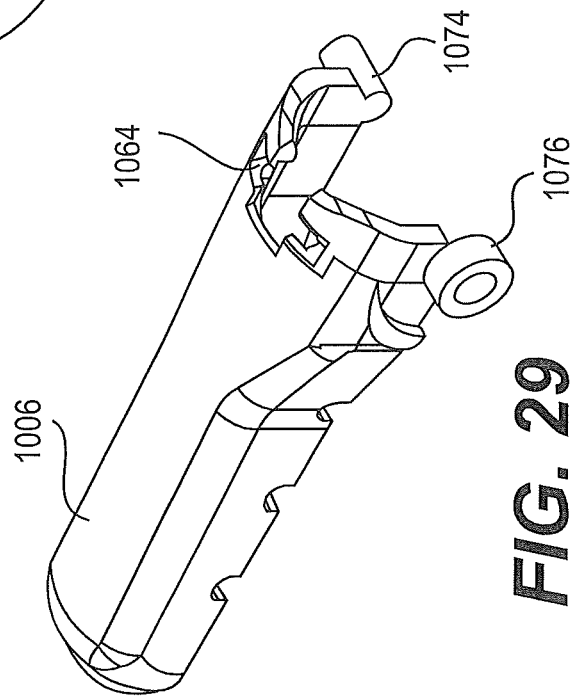

FIG. 29

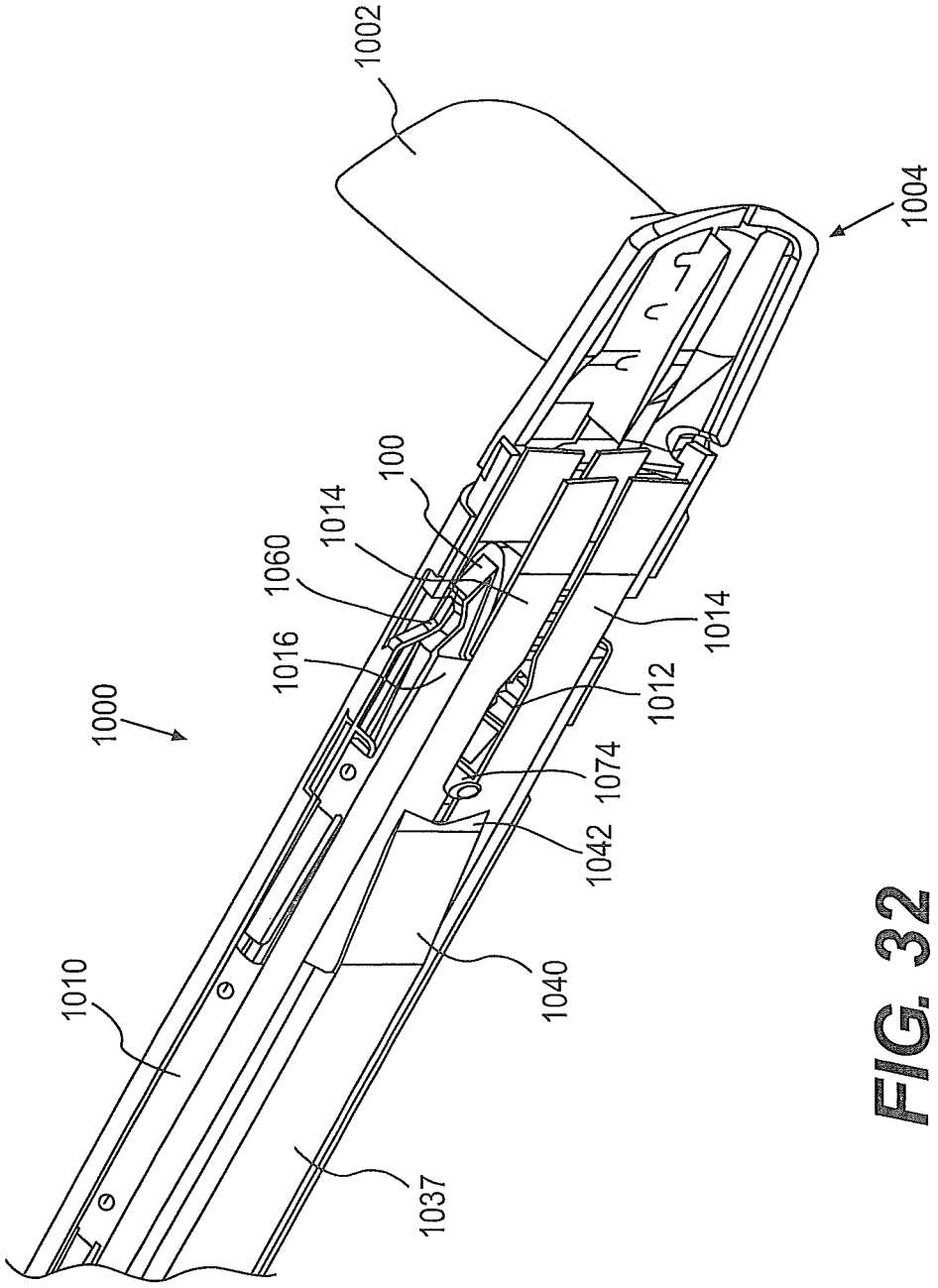
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FIG. 32

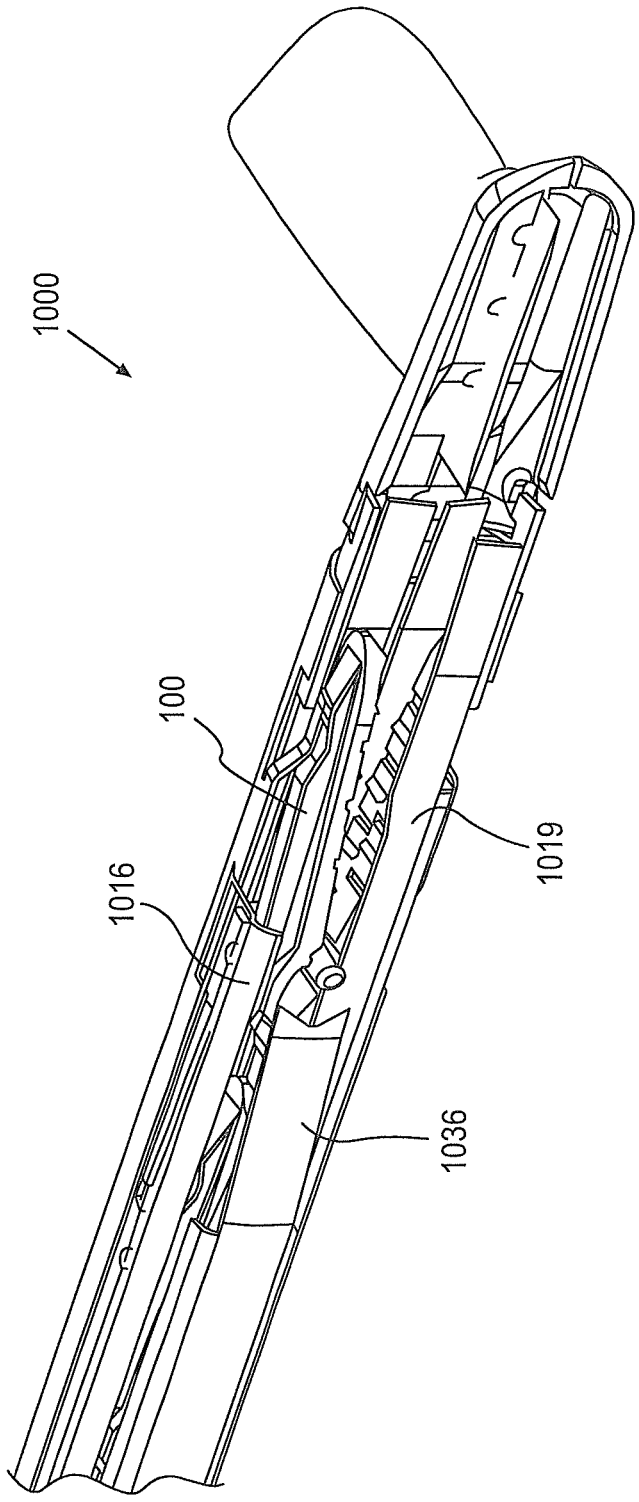

FIG. 33

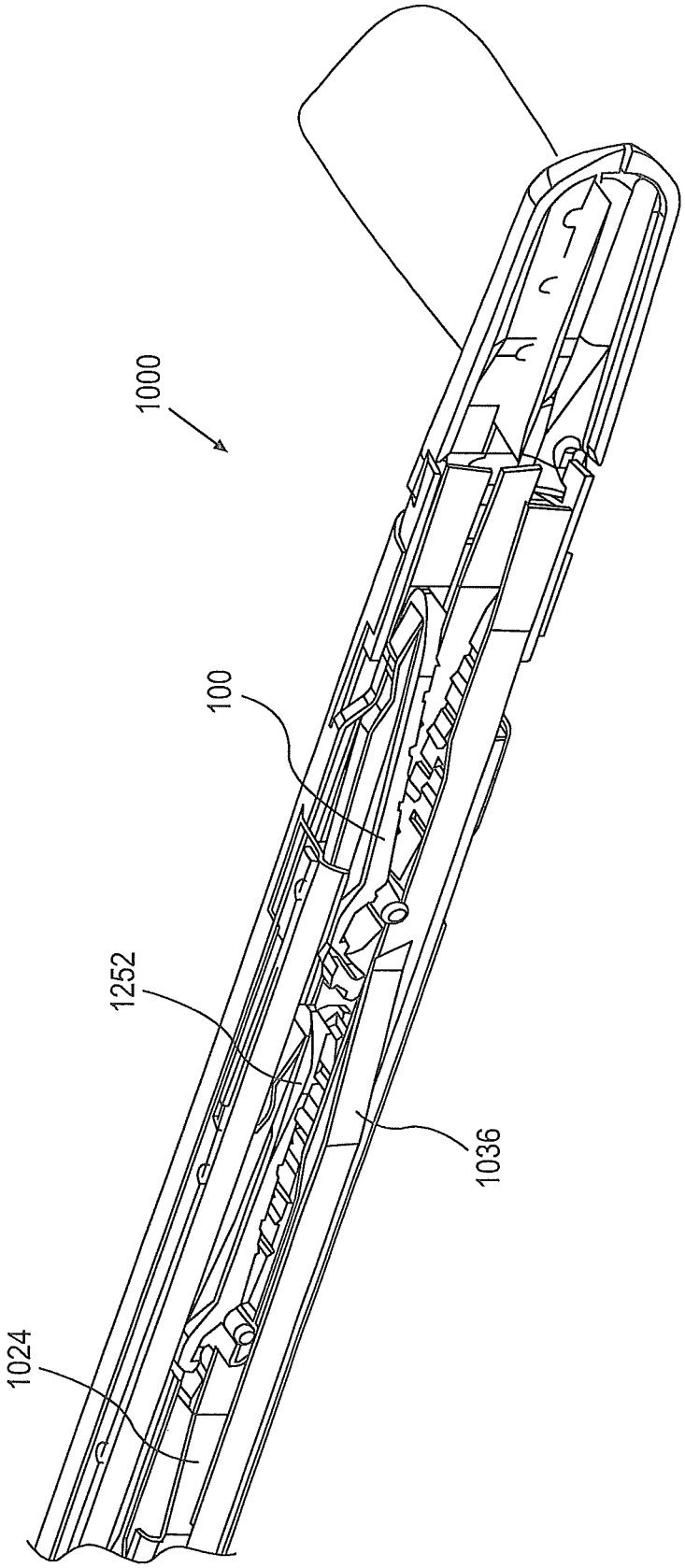

FIG. 34

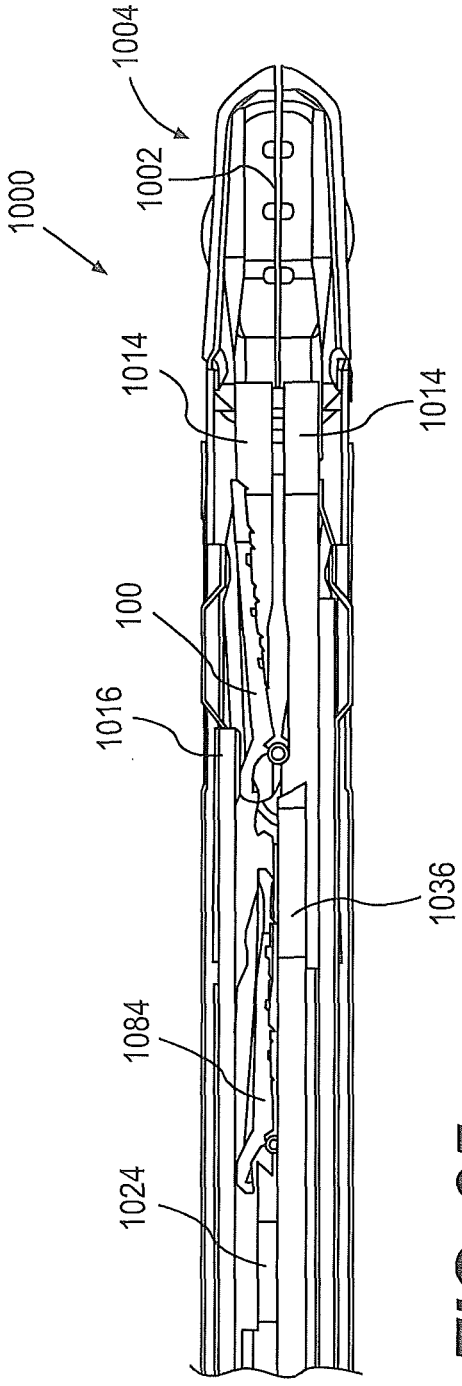
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FIG. 35

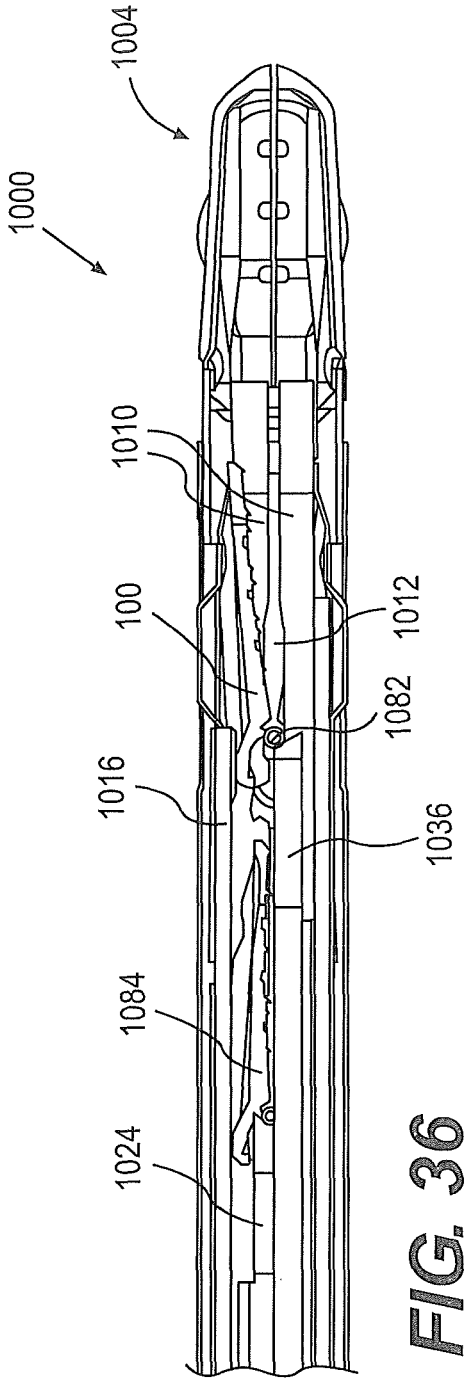
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FIG. 36

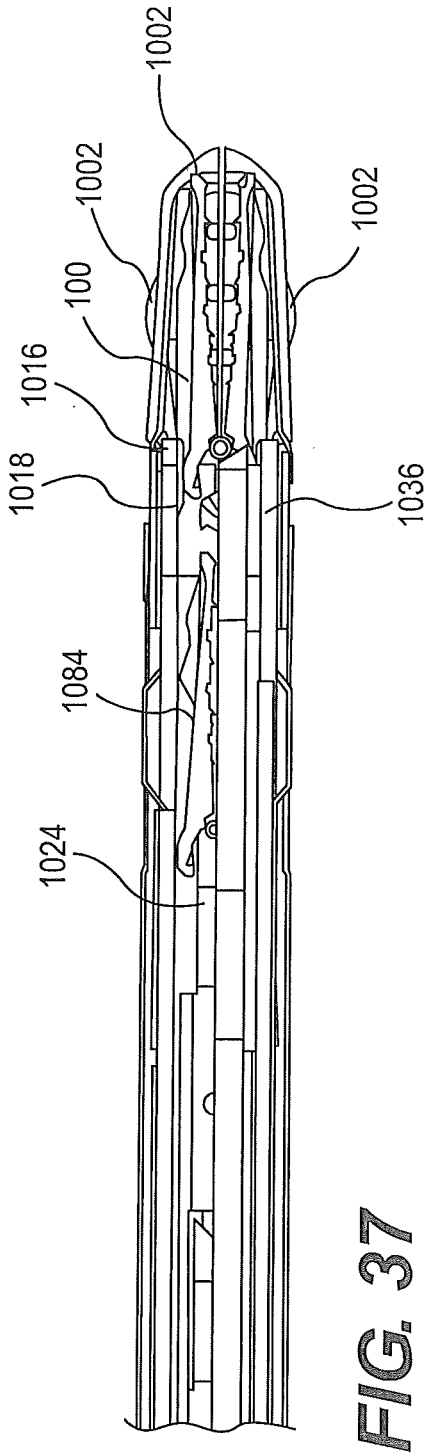
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FIG. 37

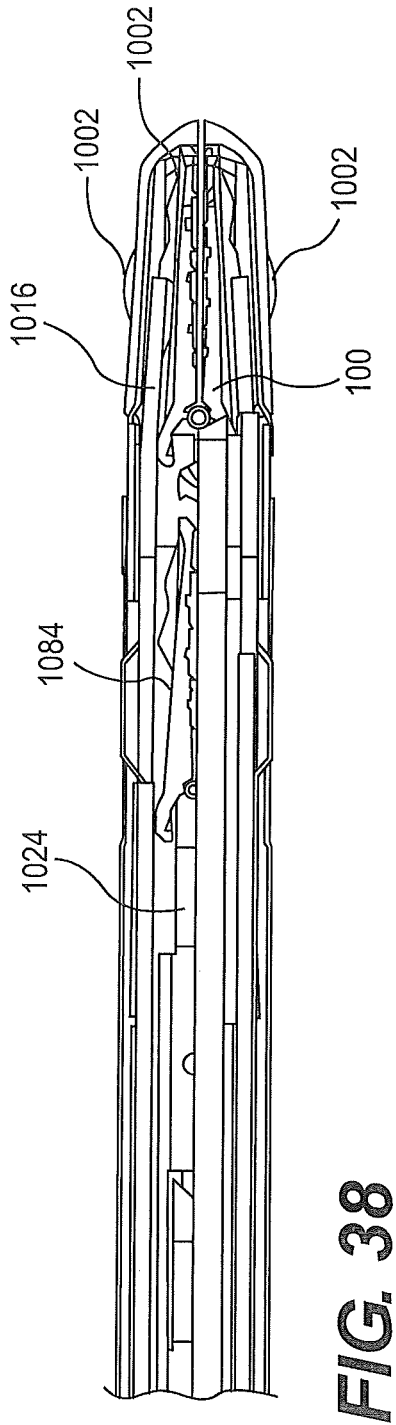
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FIG. 38

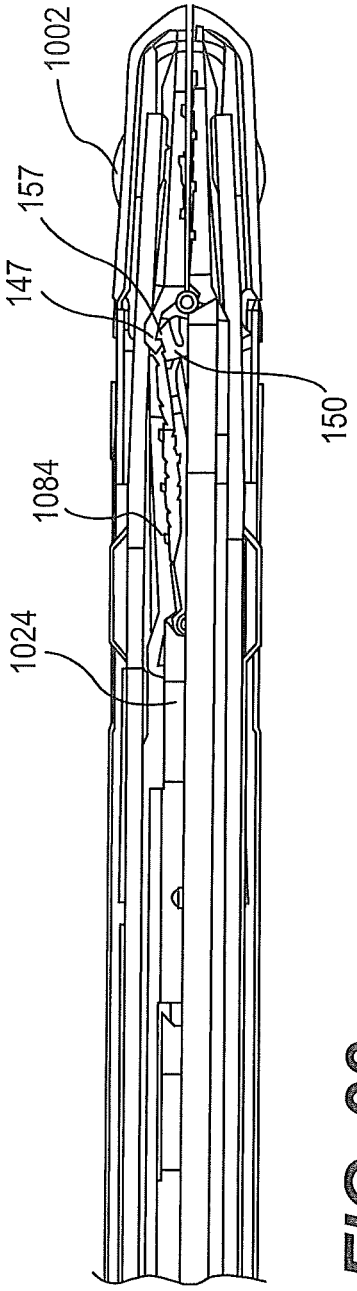

FIG. 39

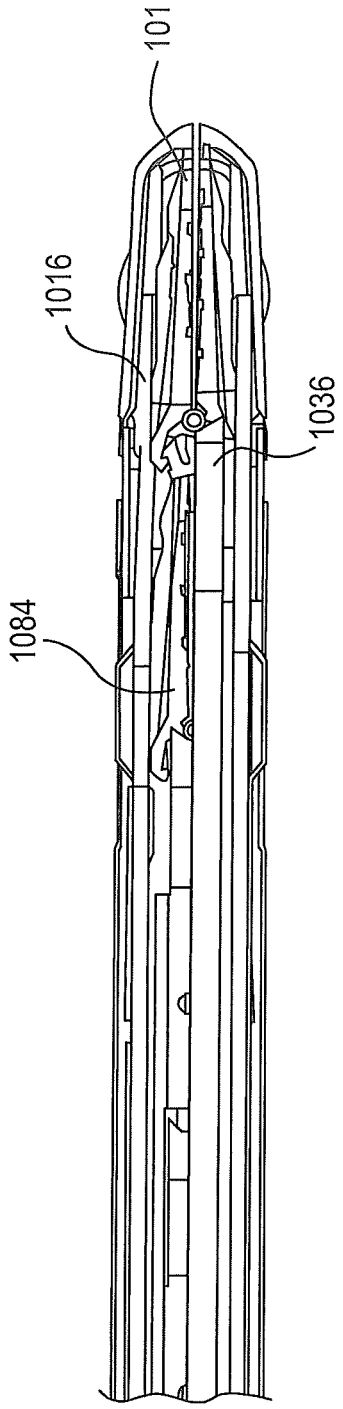

FIG. 40

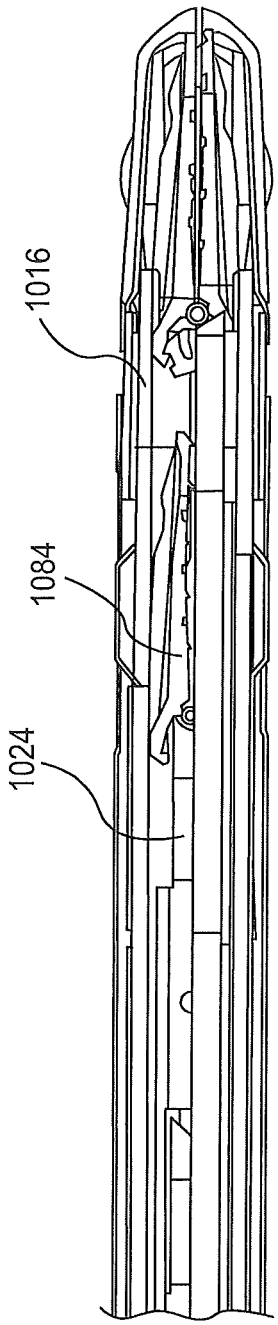

FIG. 41

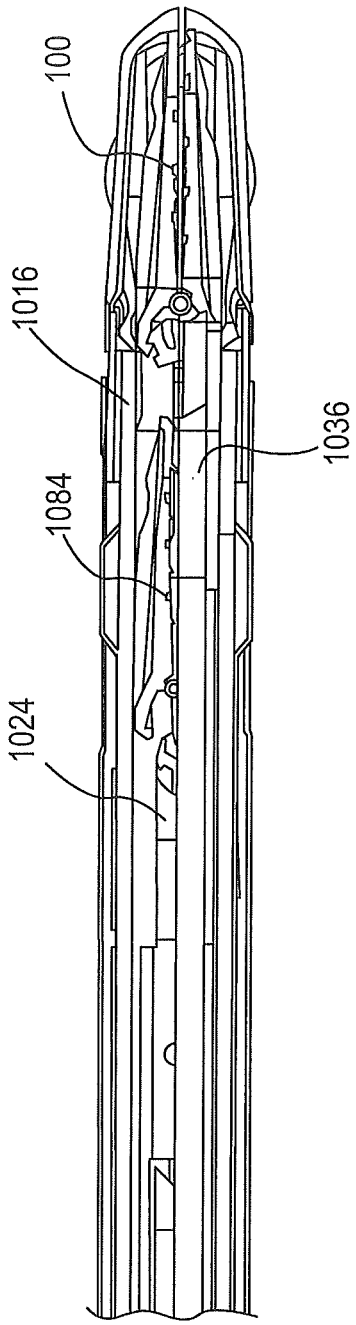

FIG. 42

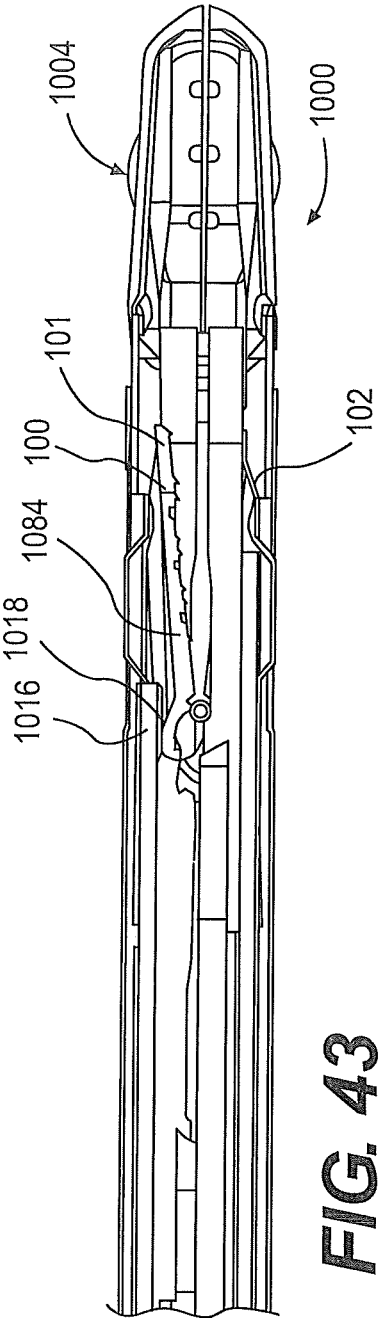

FIG. 43

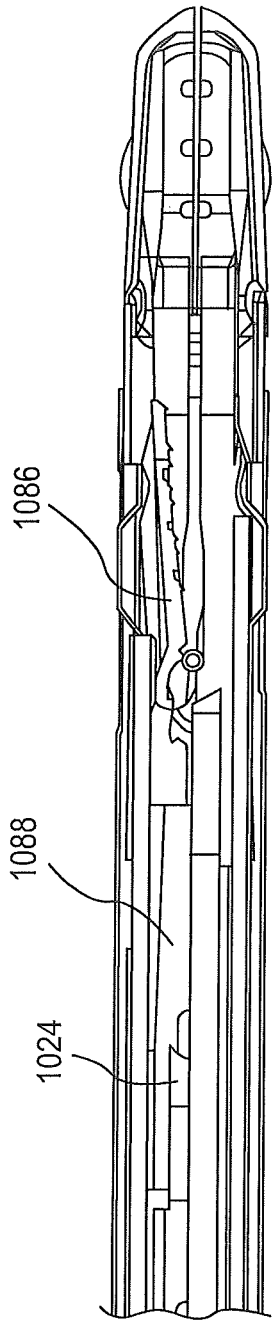

FIG. 44

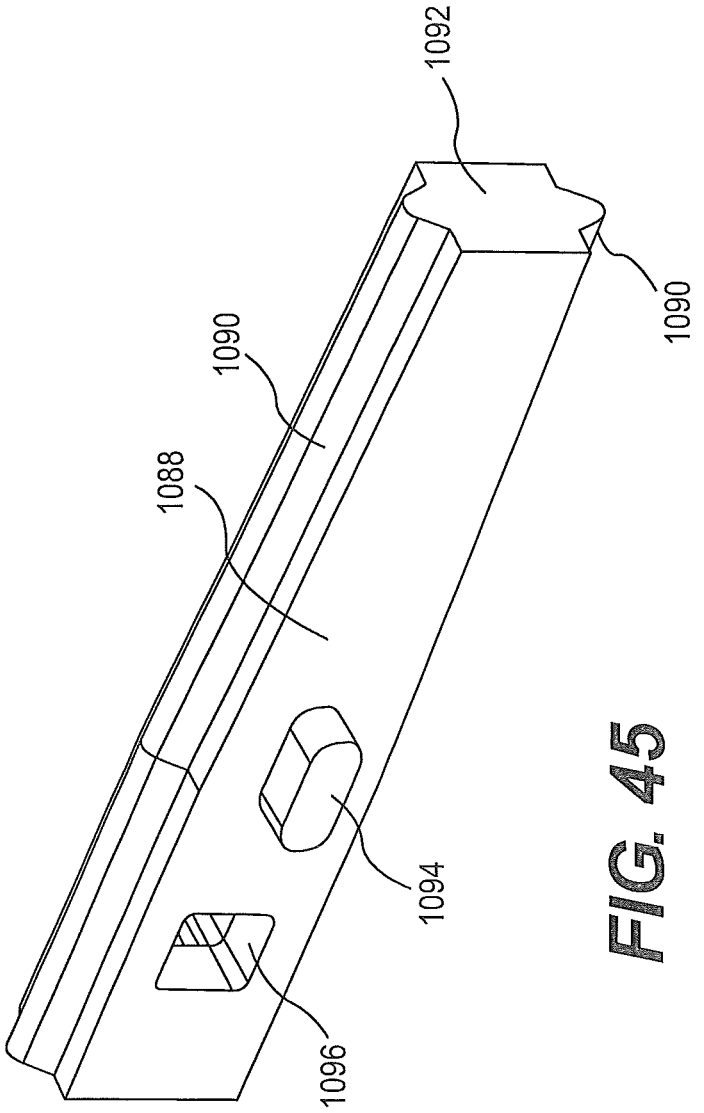

FIG. 45

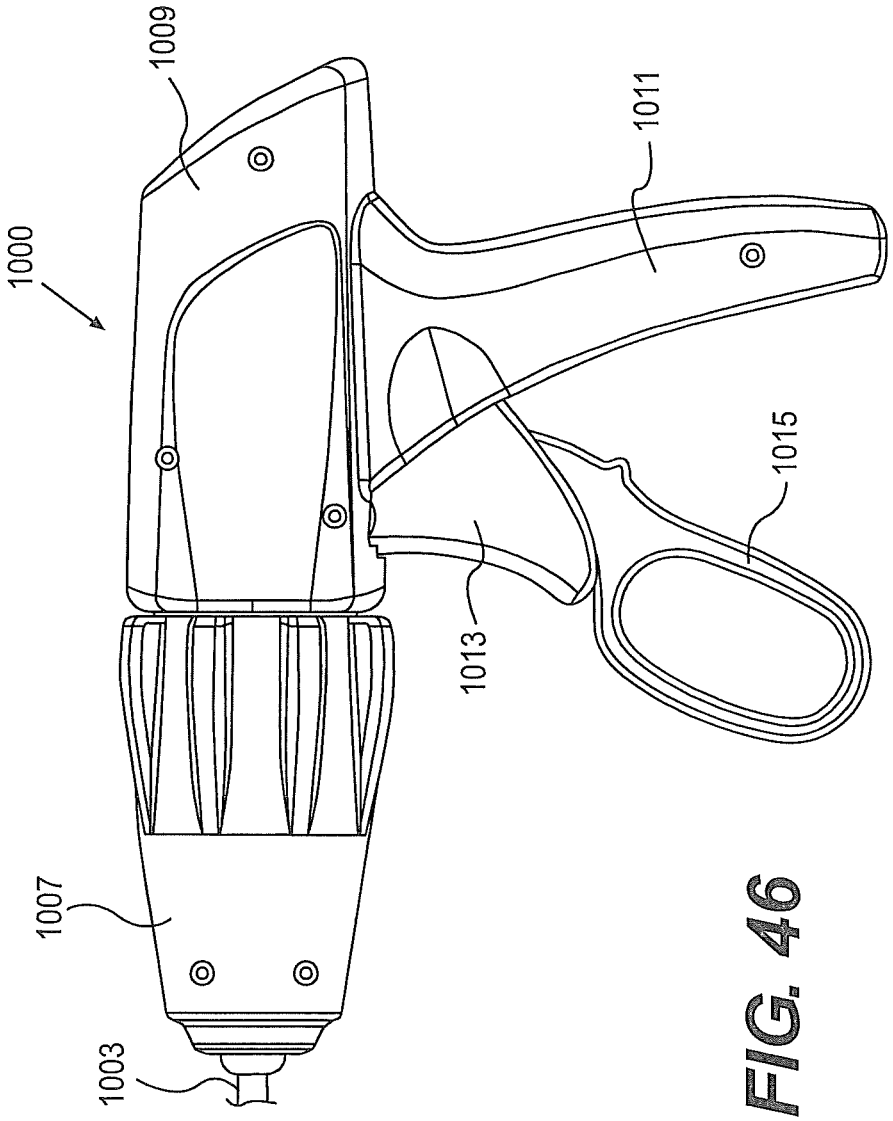

FIG. 46

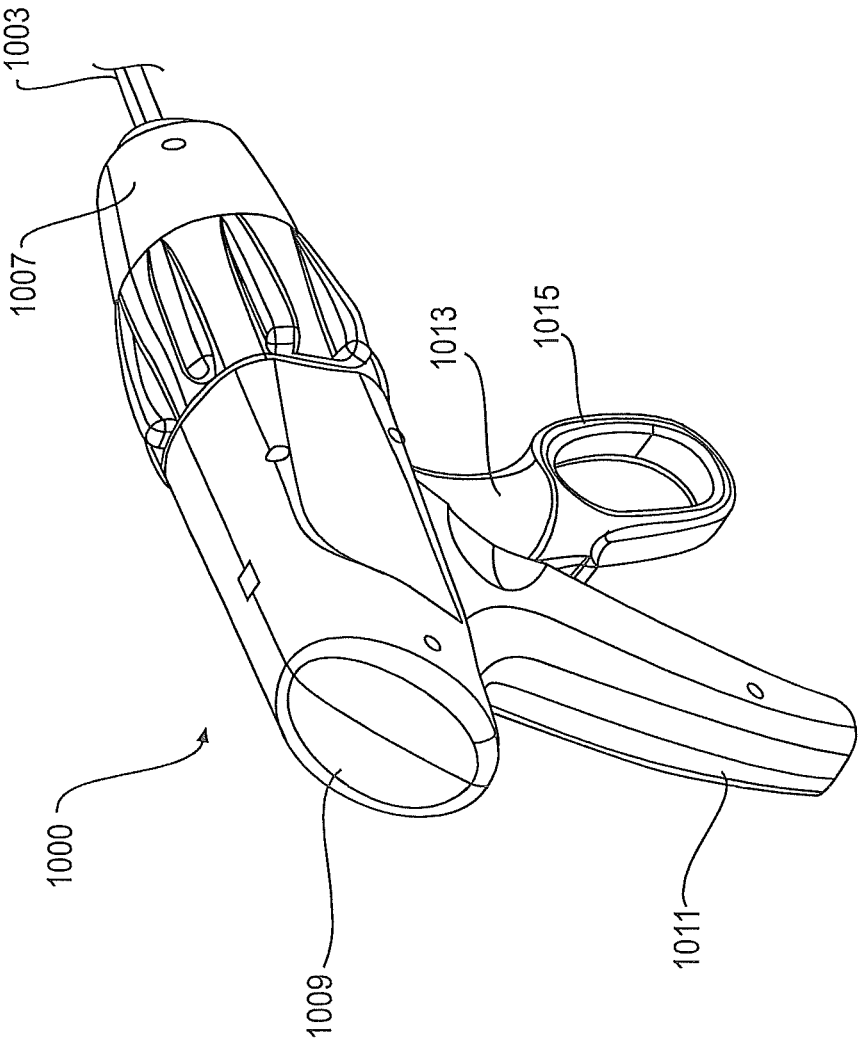

FIG. 47

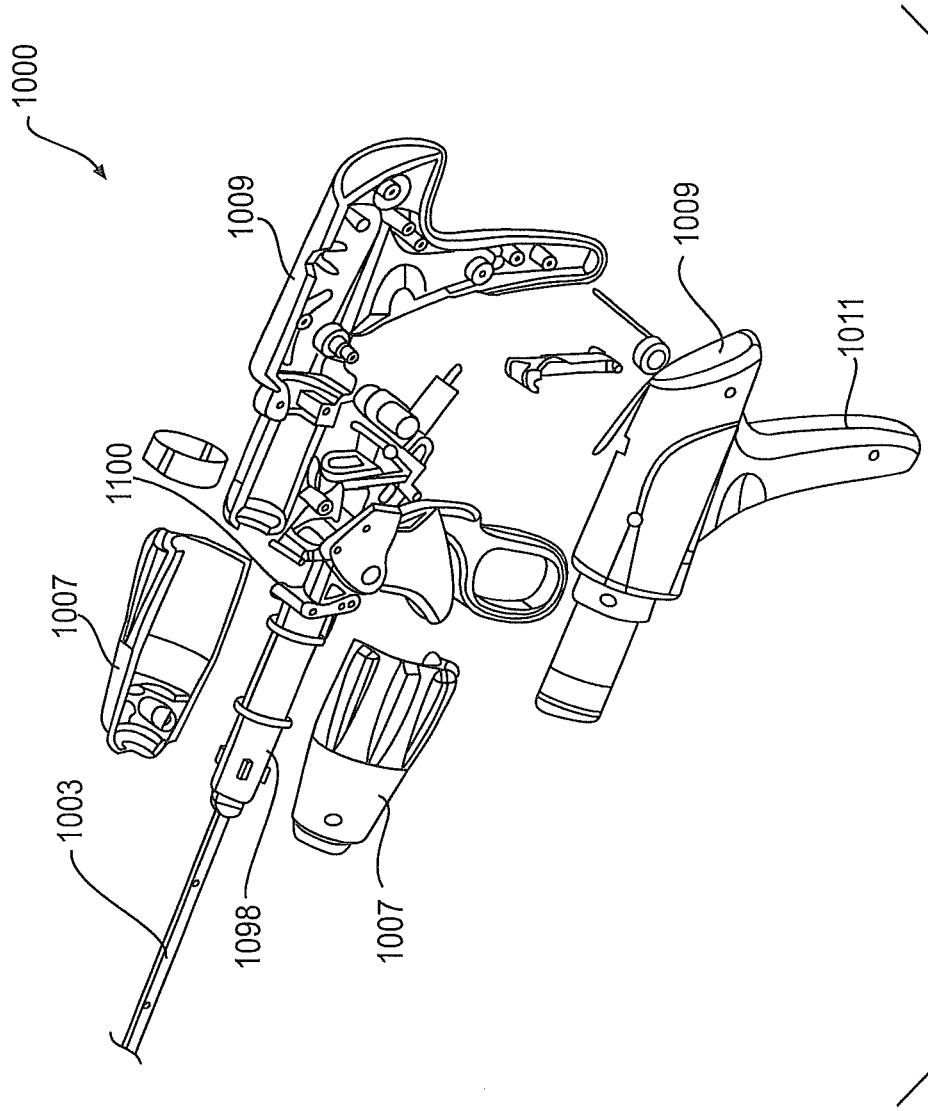

FIG. 48

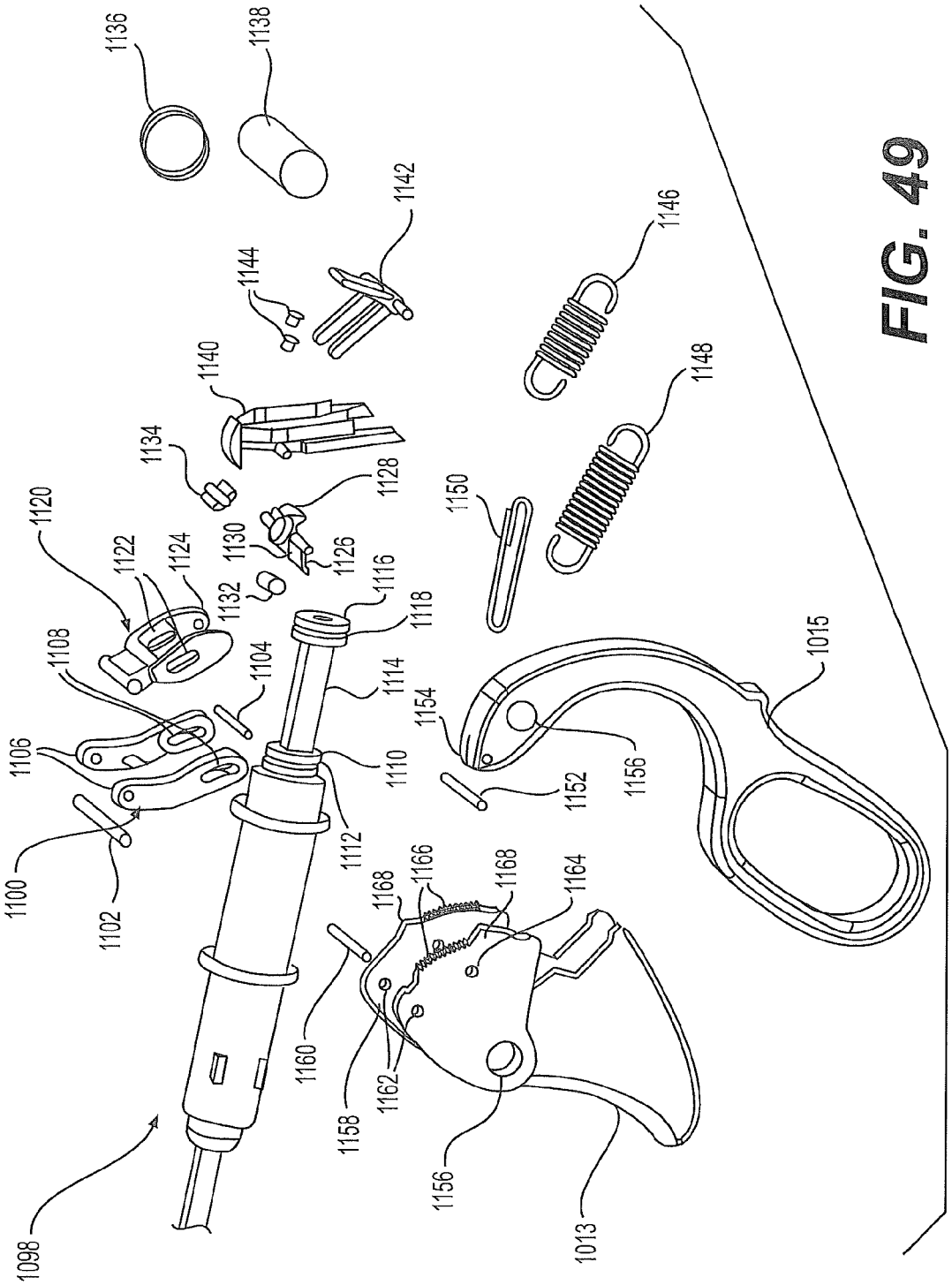
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FIG. 49

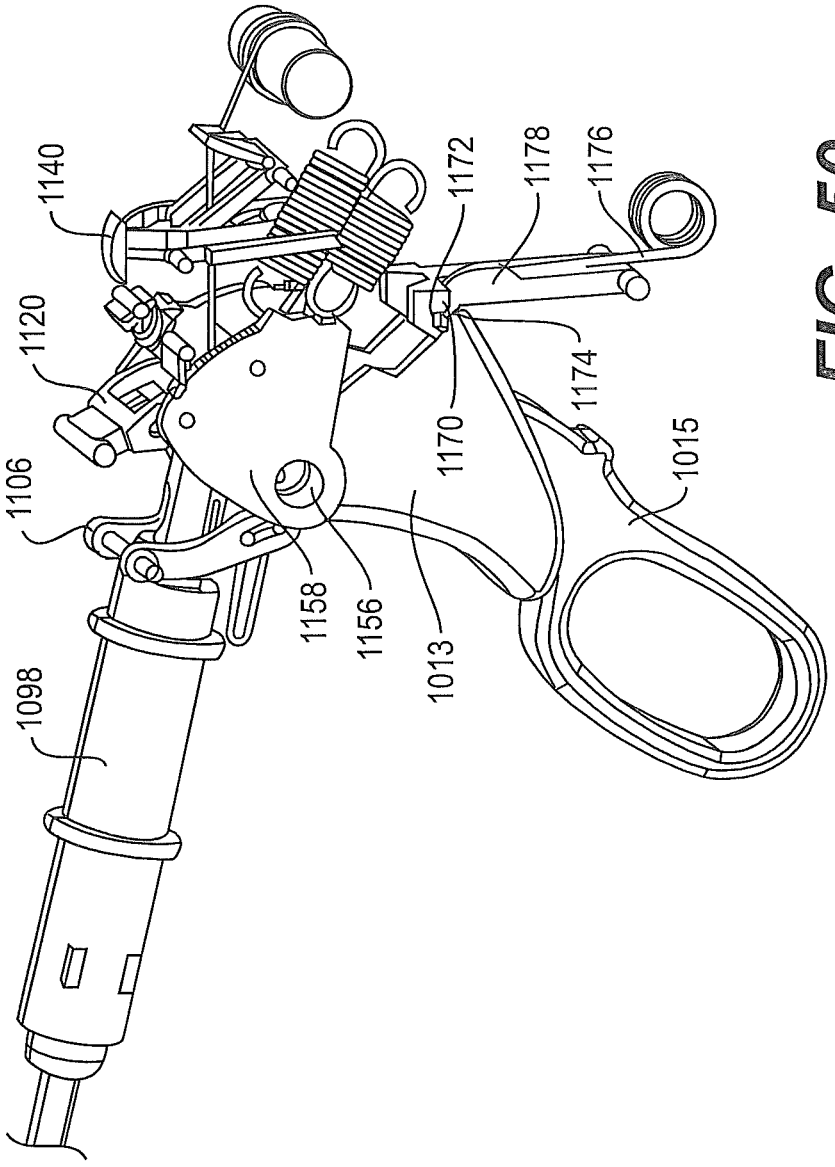
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FIG. 50

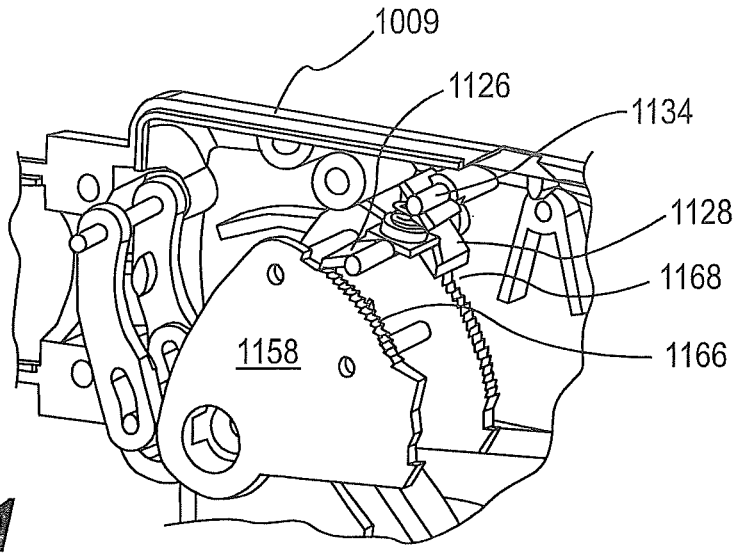


FIG. 51

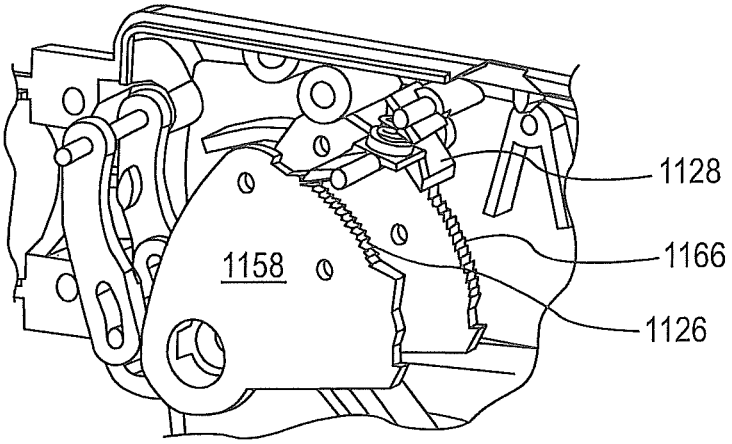


FIG. 52

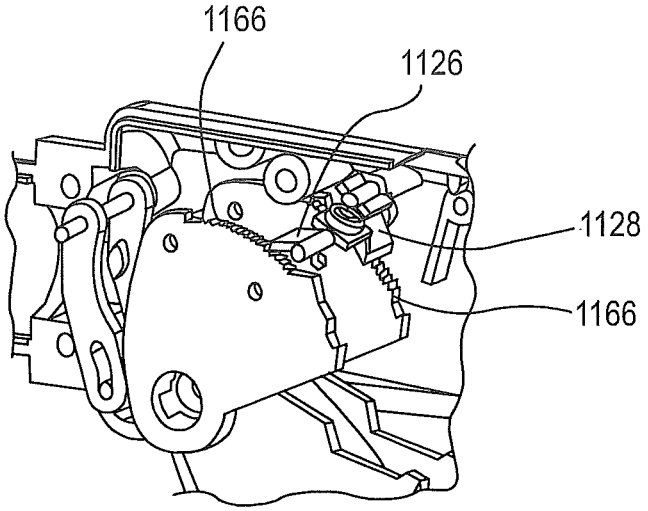


FIG. 53

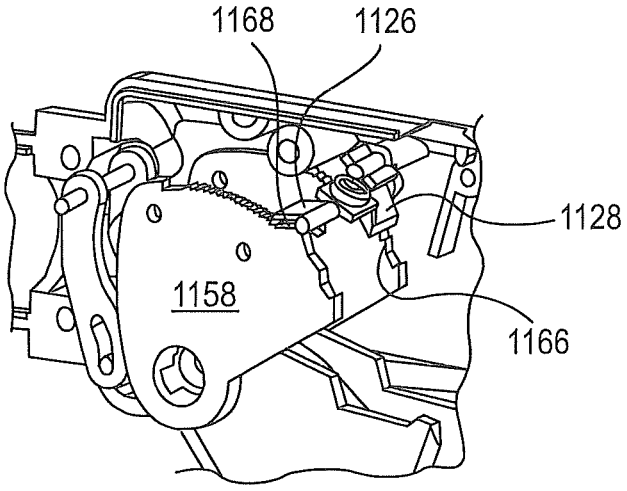


FIG. 54

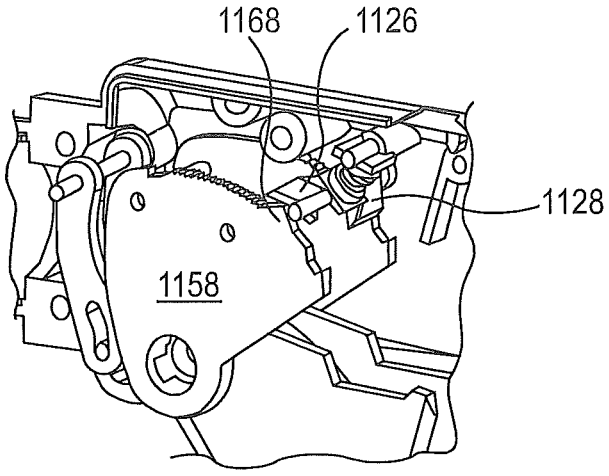


FIG. 55

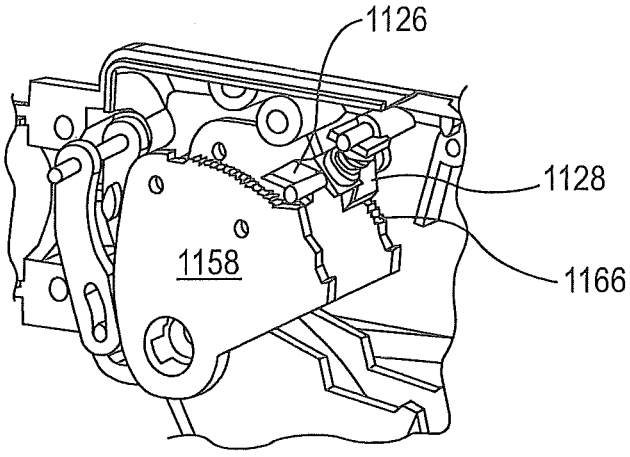


FIG. 56

FIG. 57

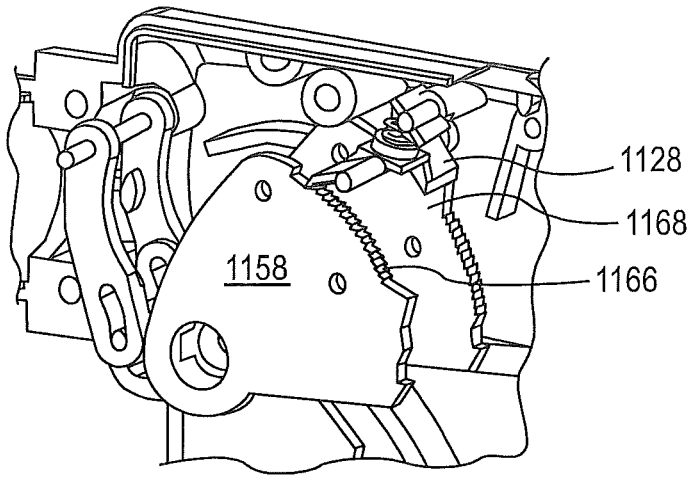
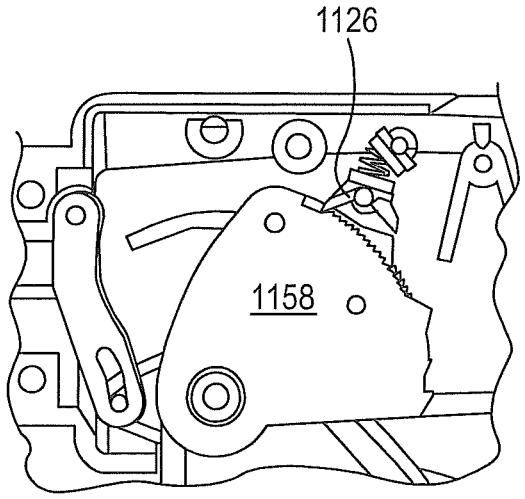


FIG. 58



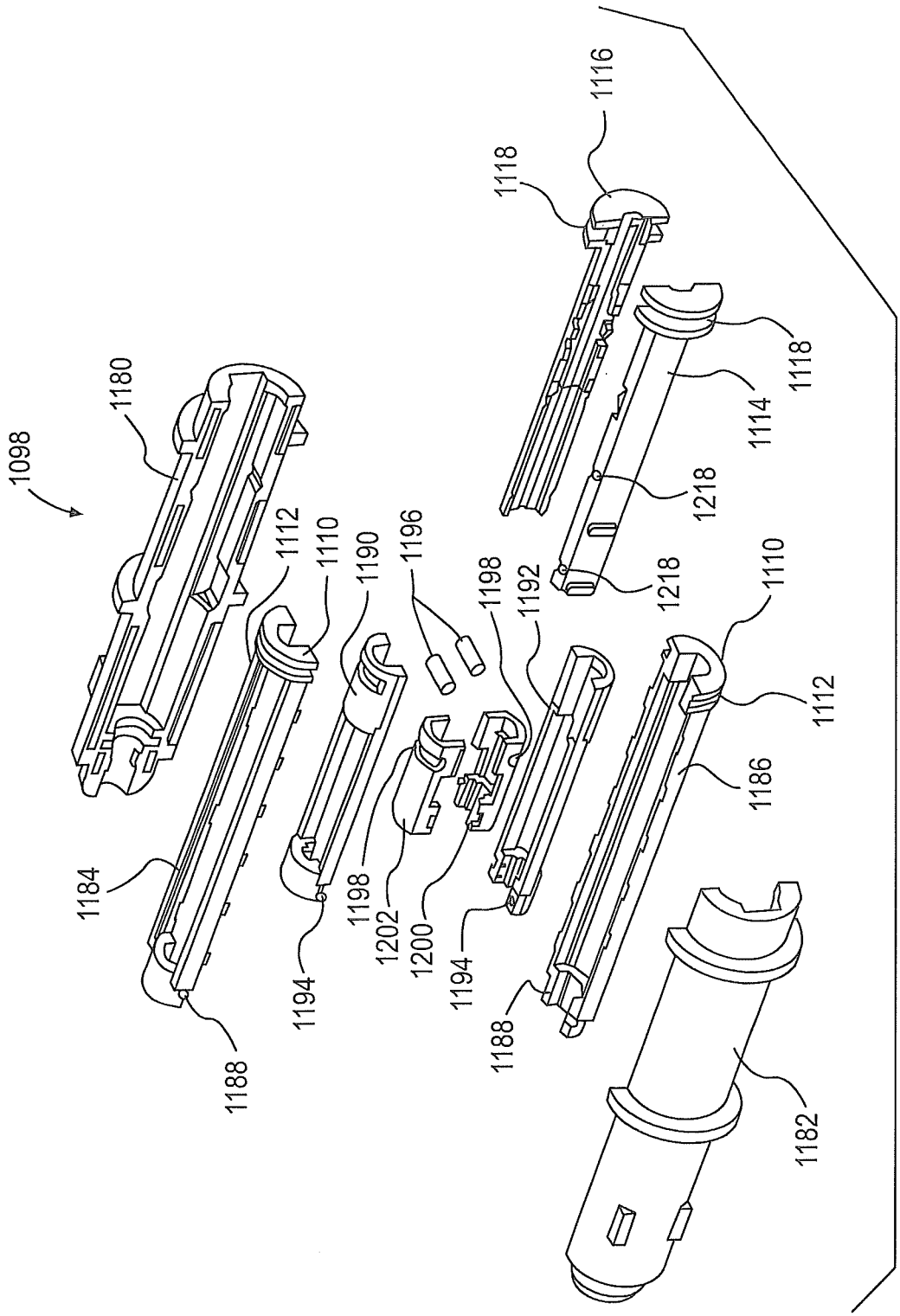

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FIG. 59

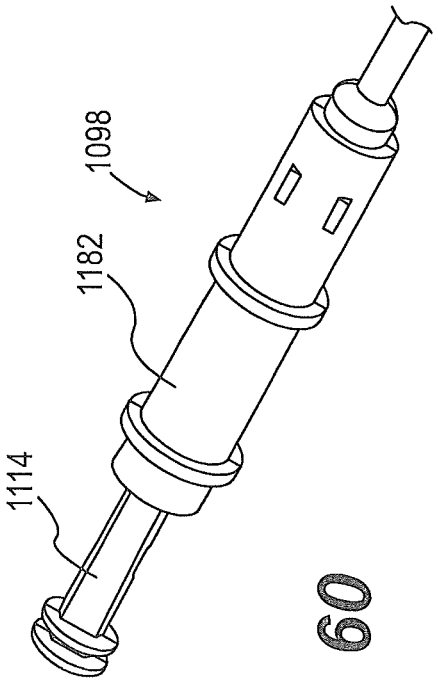

FIG. 60

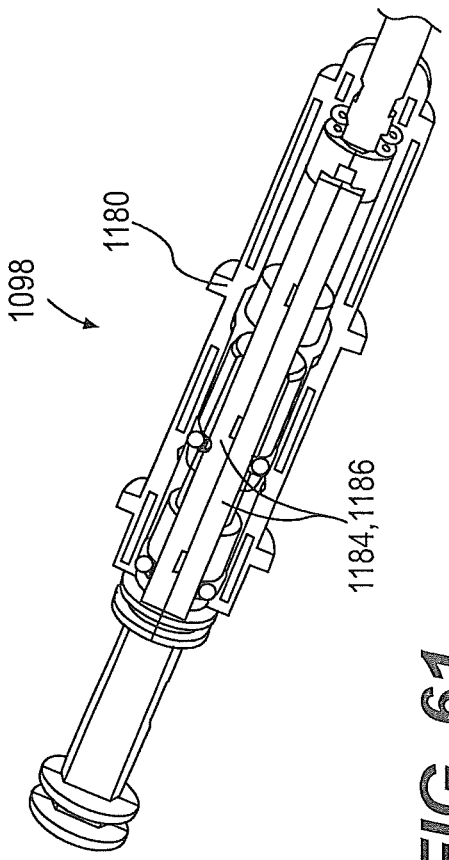

FIG. 61

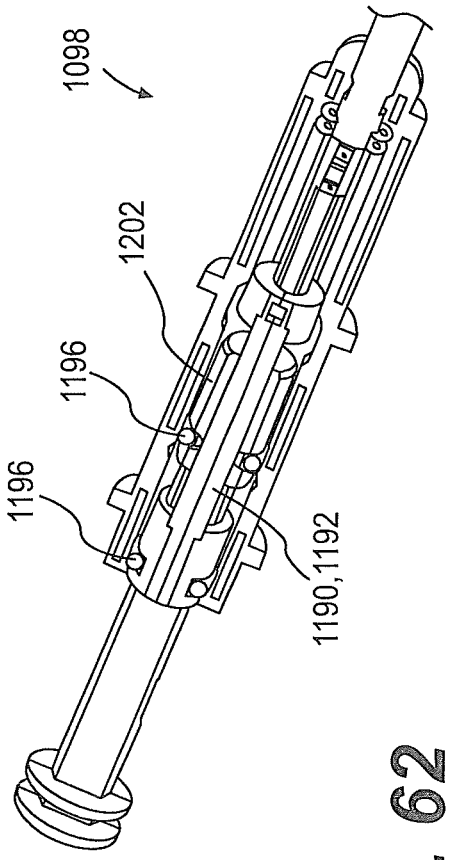
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FIG. 62

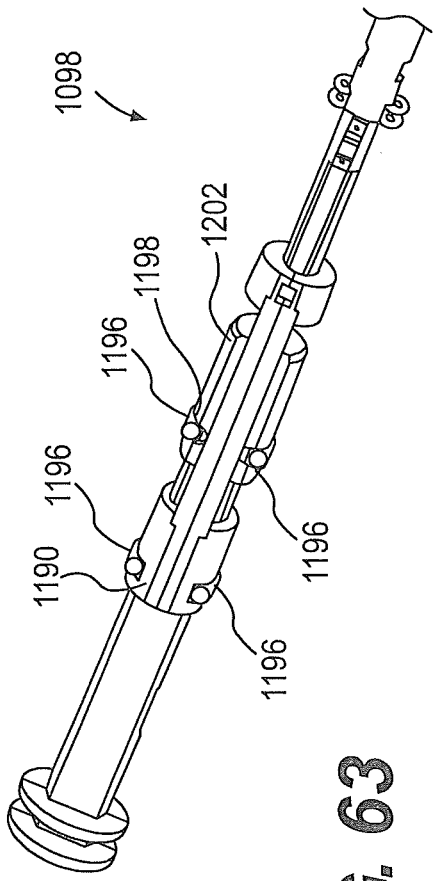
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FIG. 63

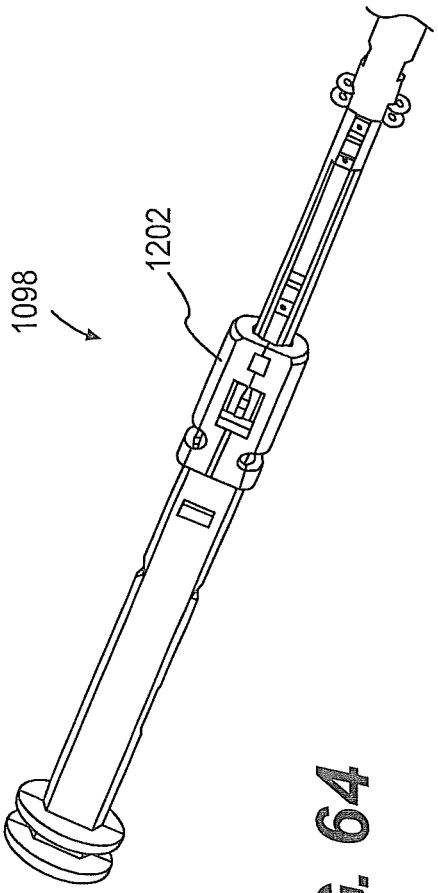

FIG. 64

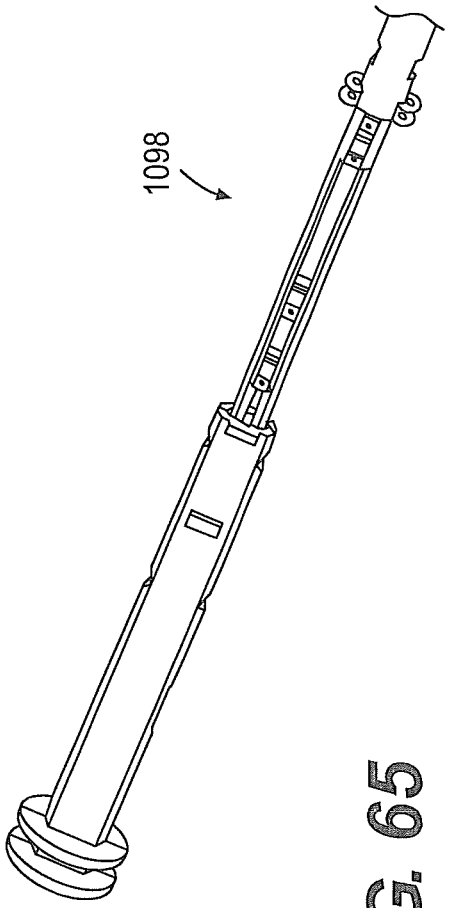

FIG. 65

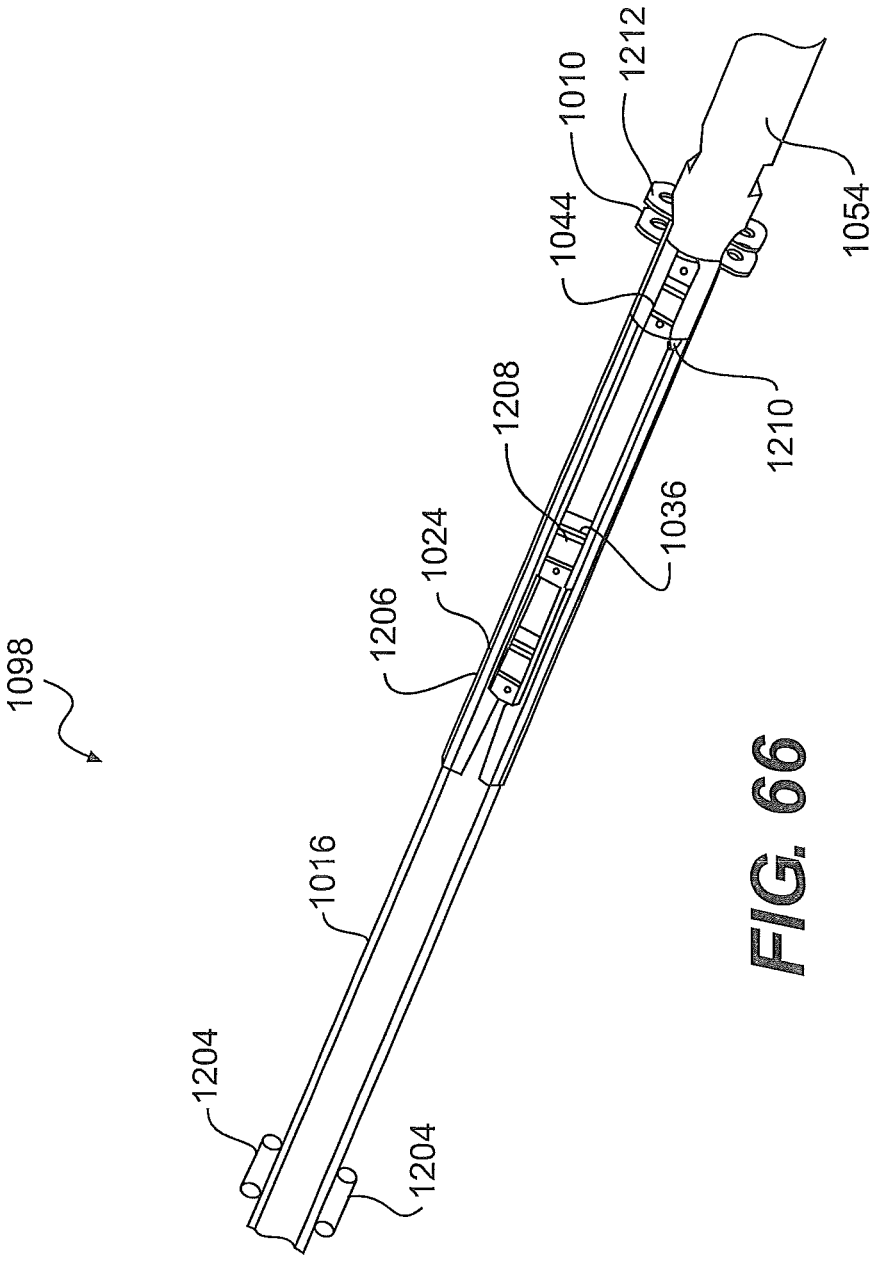
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FIG. 66

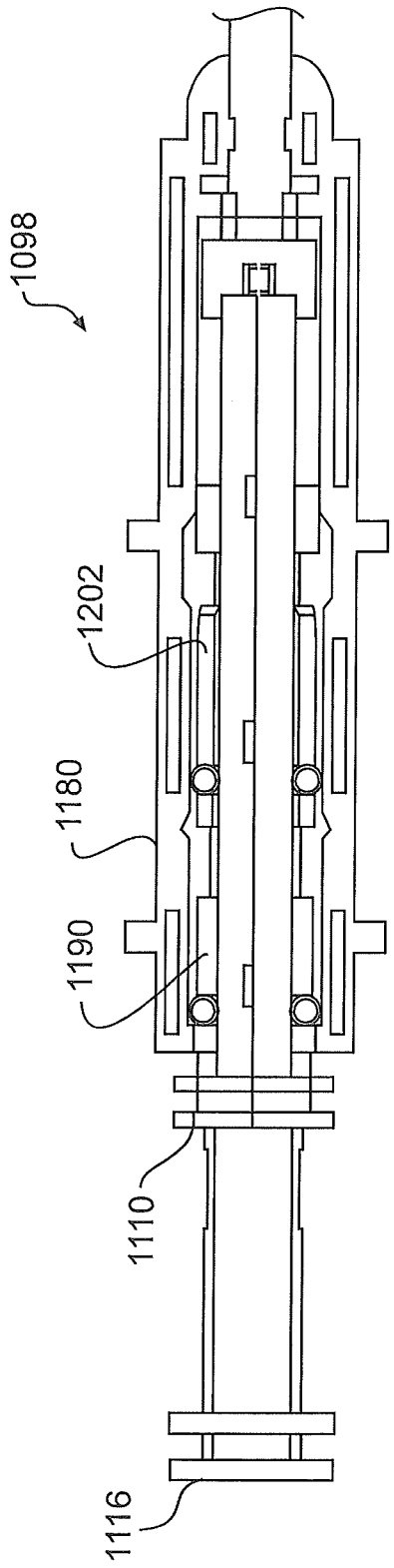


FIG. 67

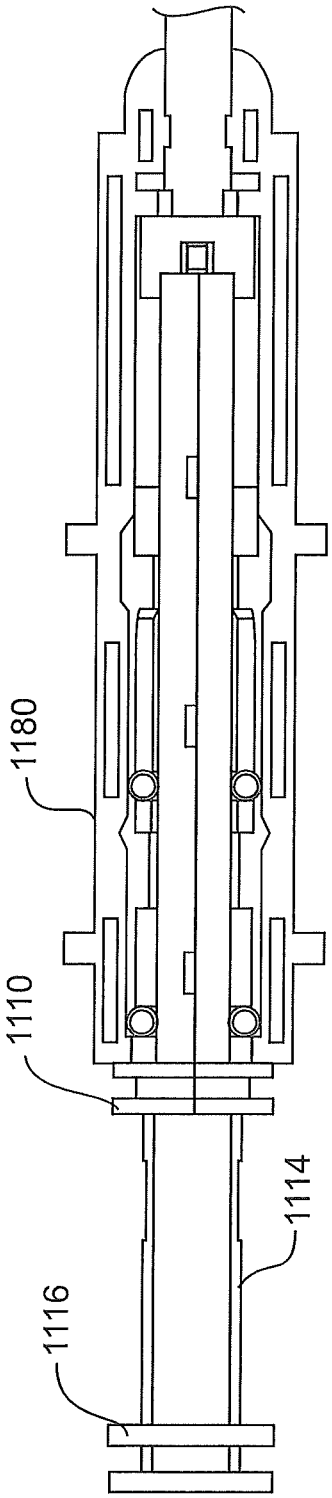


FIG. 68

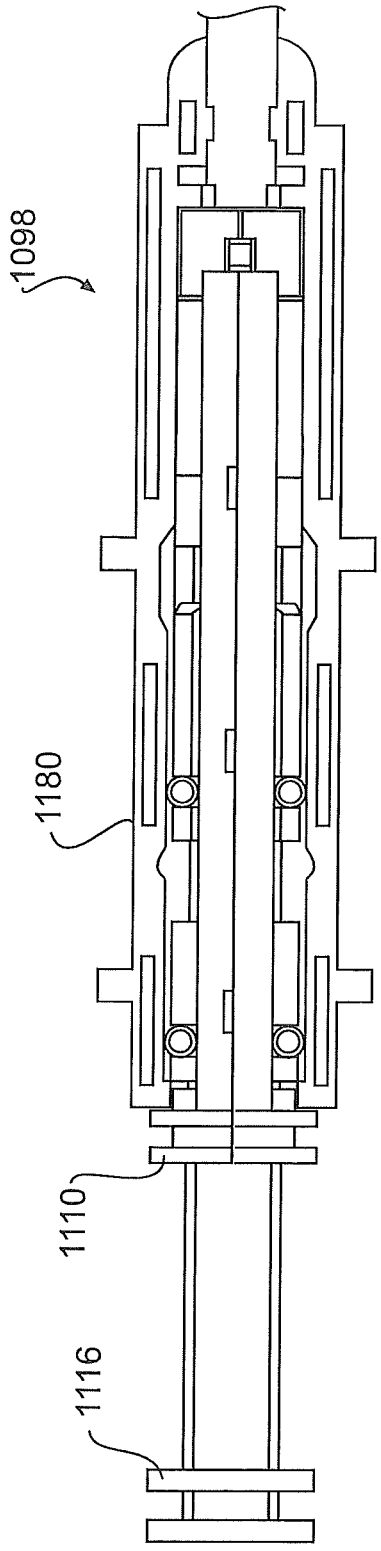
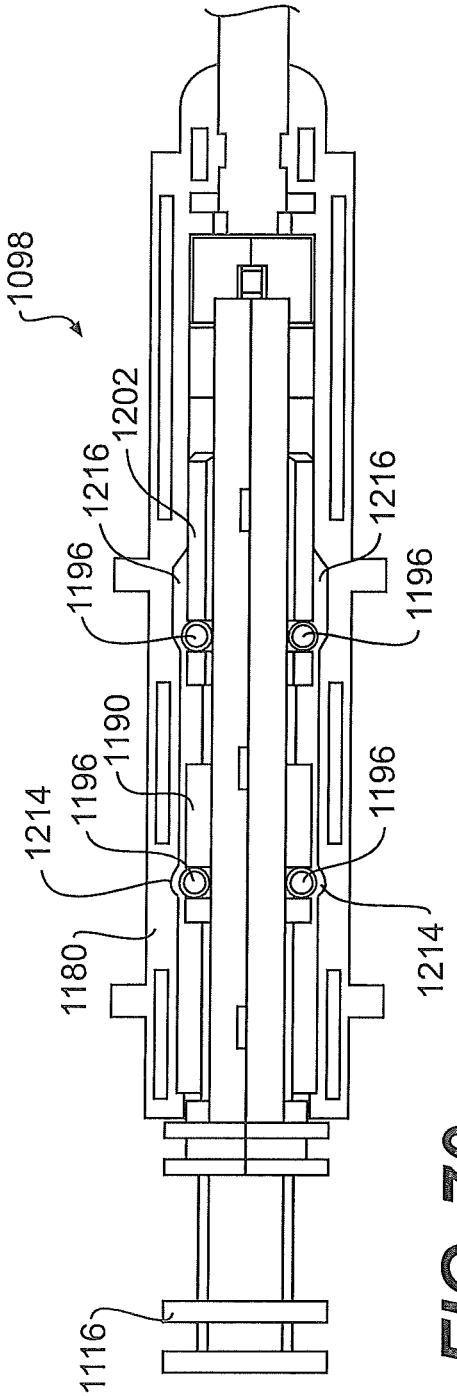

1098
1180
1110
1116

FIG. 69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1216
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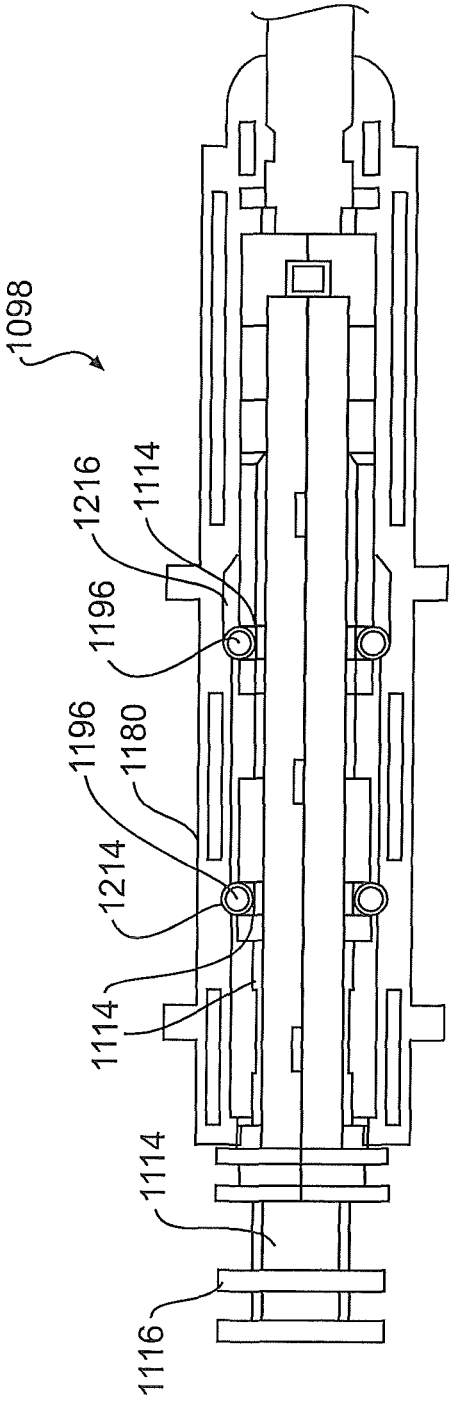
1196
1196
1190
1196
1196
1214
1214
1180
1116

FIG. 70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1114
1196
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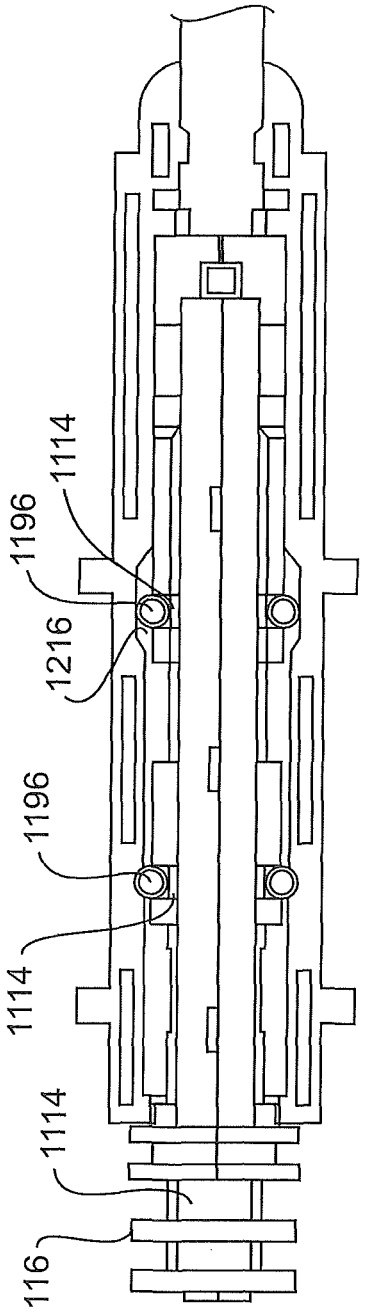
1114
1116

FIG. 71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1196
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1114
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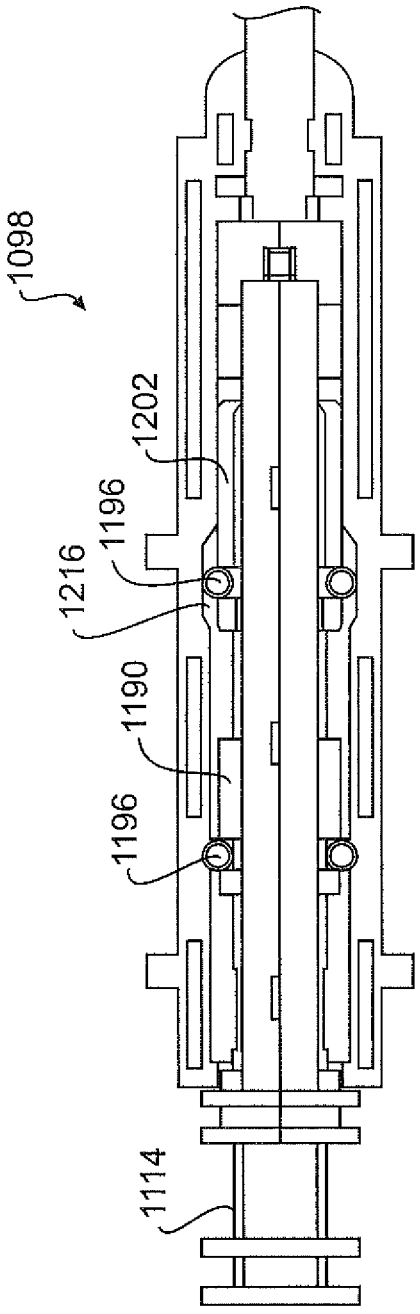
1116

FIG. 72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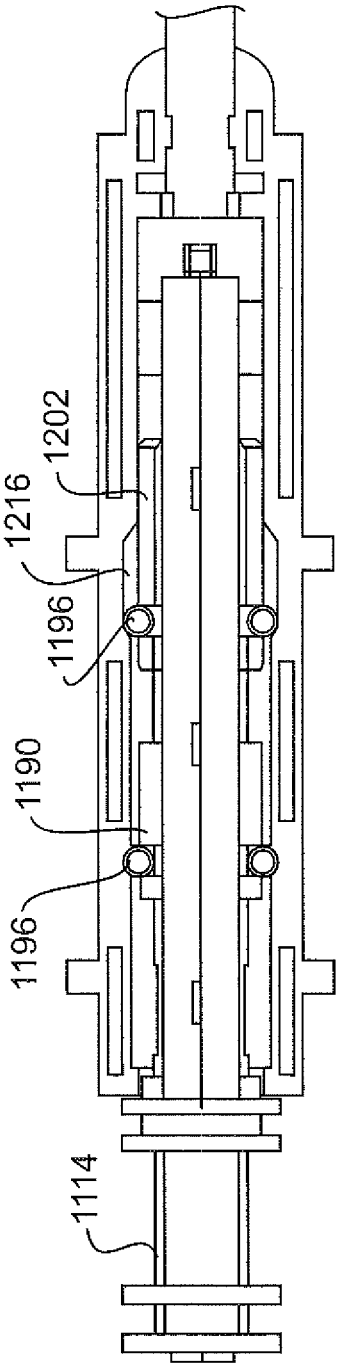
1202
1196
1216
1190
1196
1114

FIG. 73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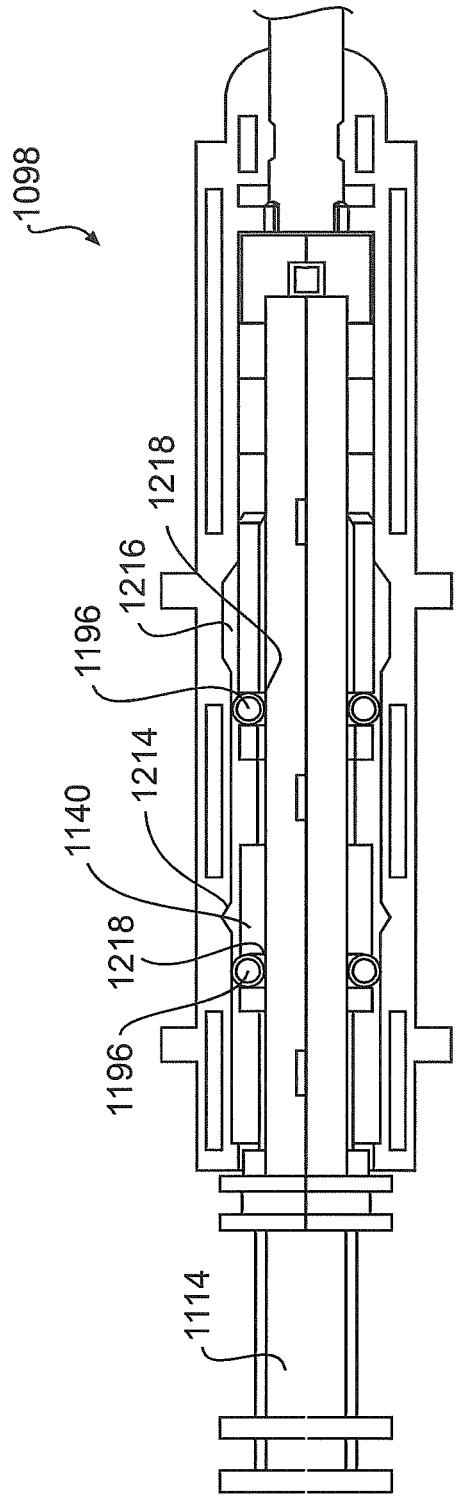
1216
1196
1190
1196
1114

FIG. 74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1216
1196
1214
1140
1218
1196
1114

FIG. 75

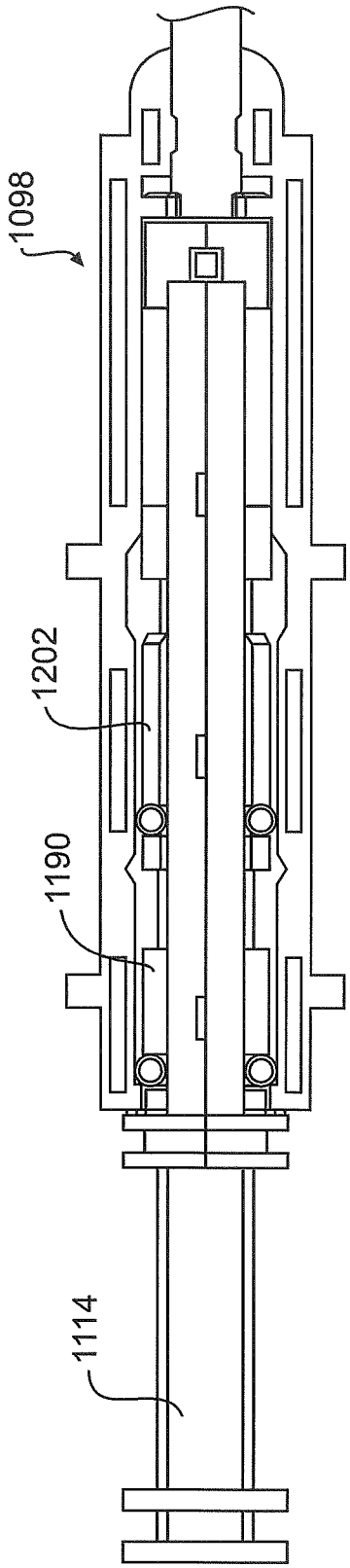

1098
1202
1190
1114

FIG. 76

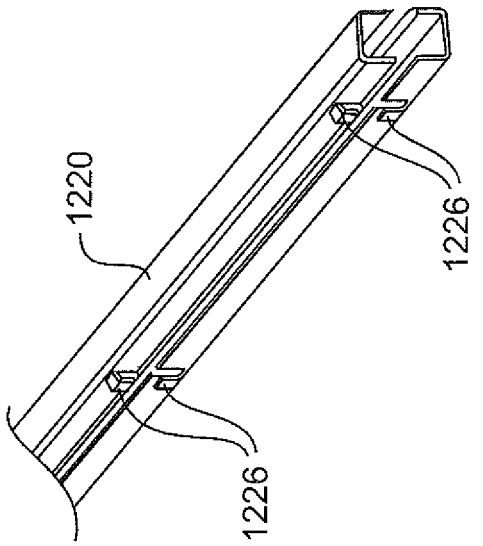


FIG. 78

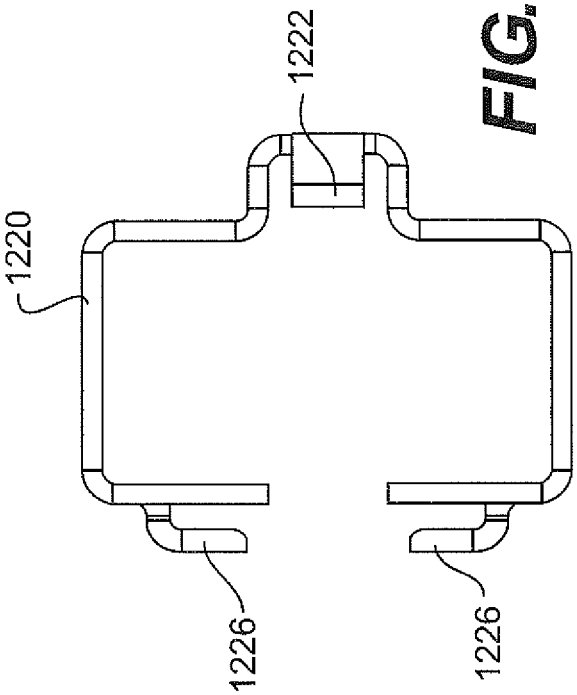


FIG. 79

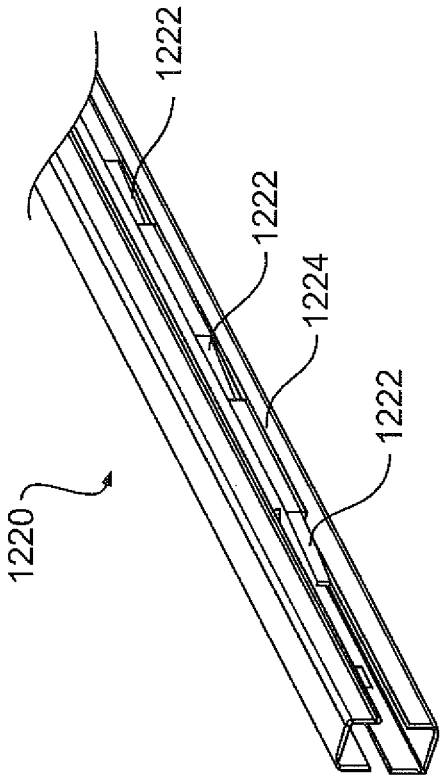


FIG. 77

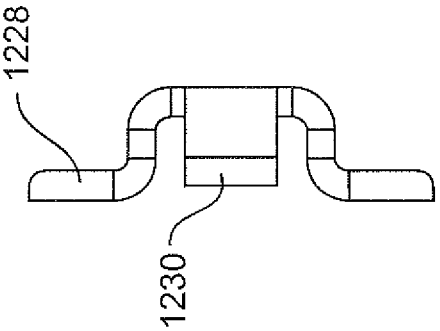


FIG. 81

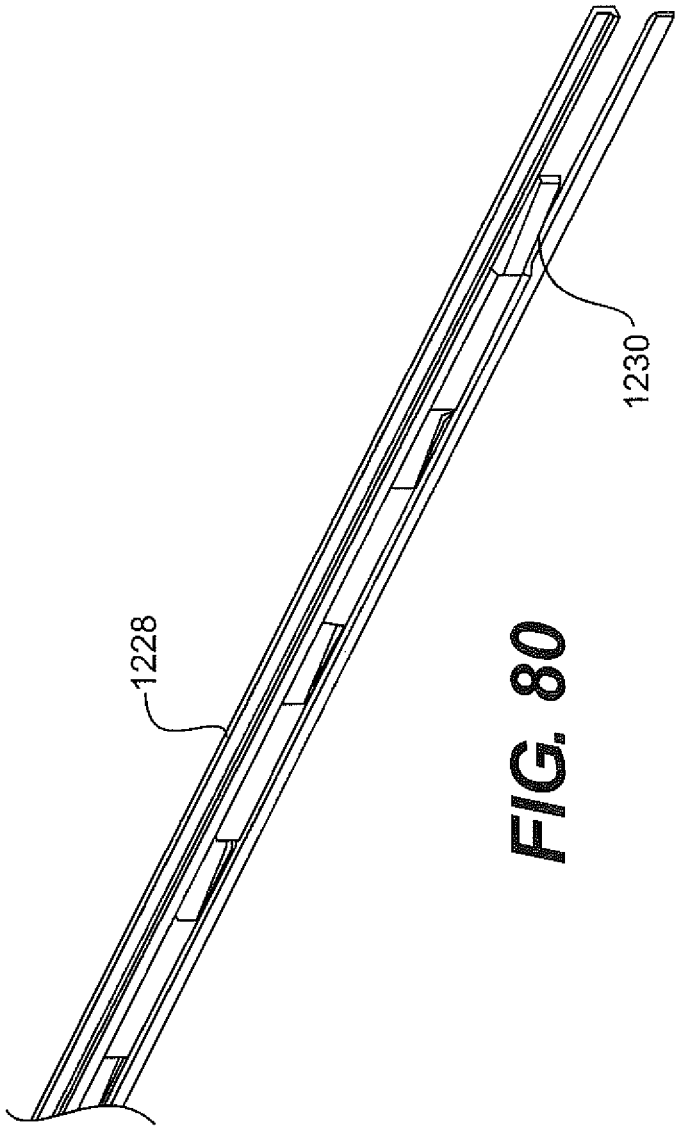


FIG. 80

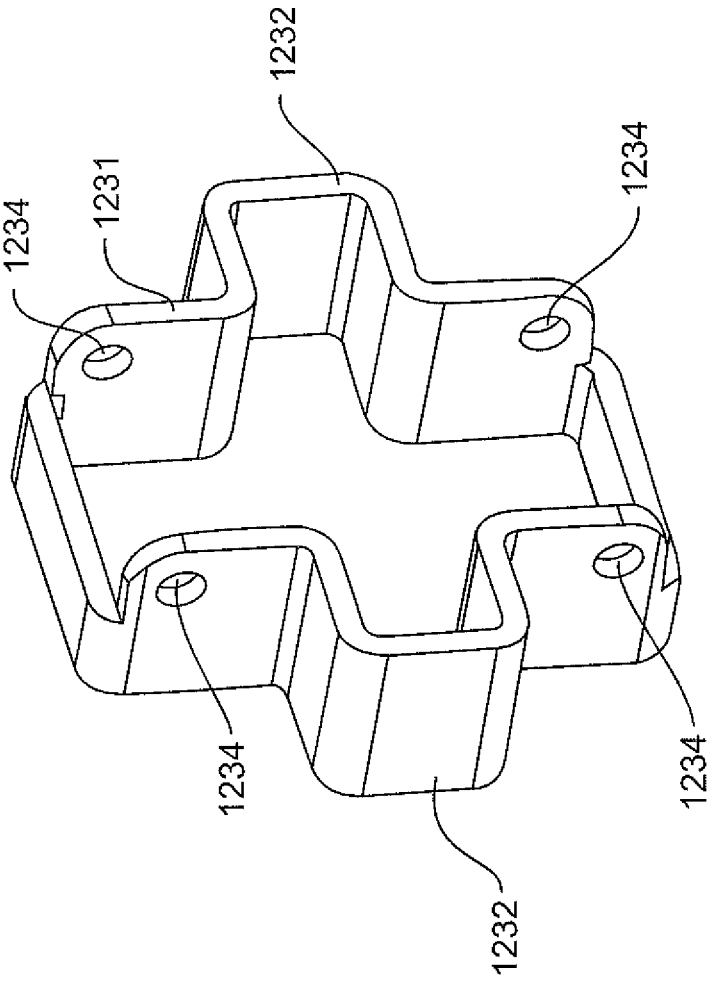


FIG. 82

FIG. 83

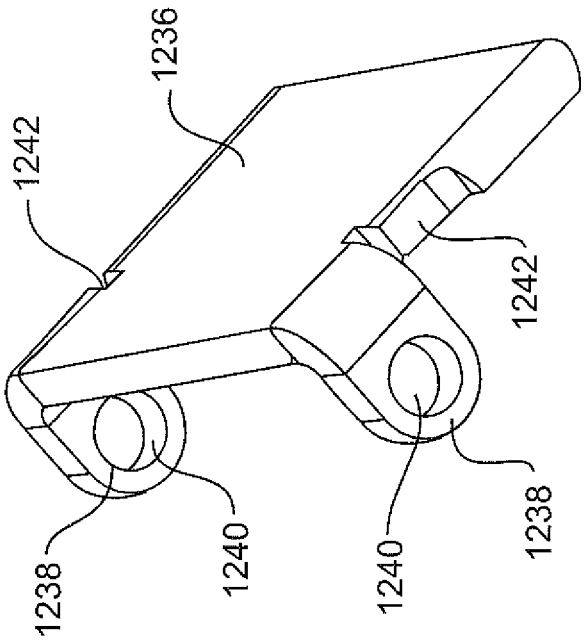
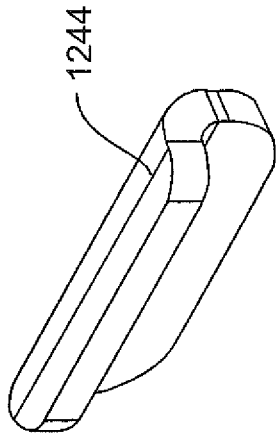


FIG. 84



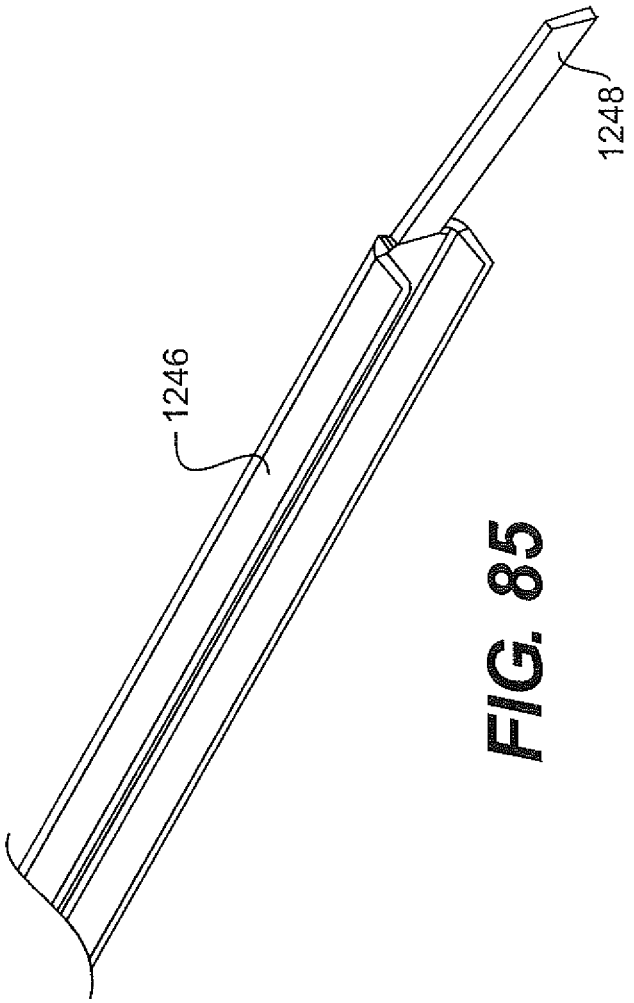


FIG. 85

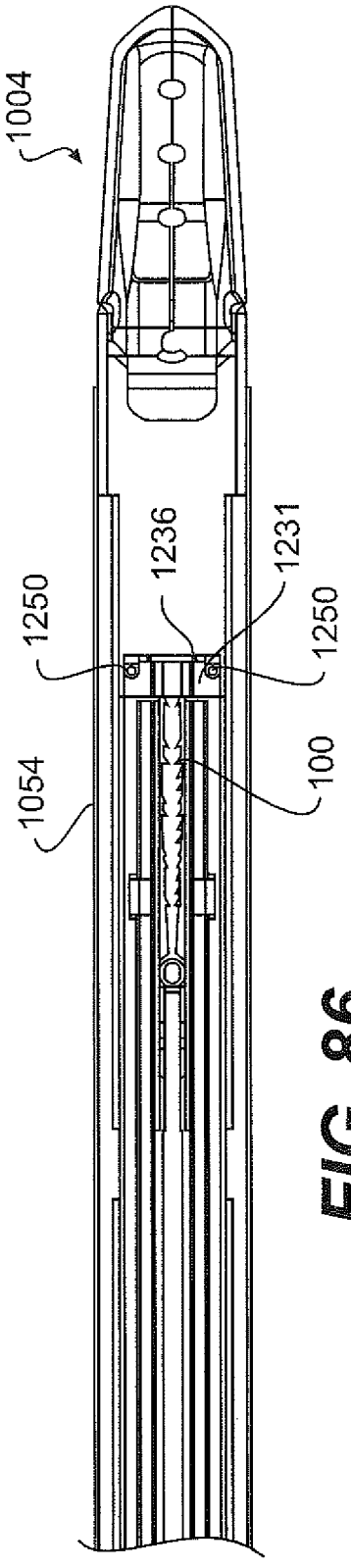

1004
1250
1236
1231
1250
1054
100

FIG. 86

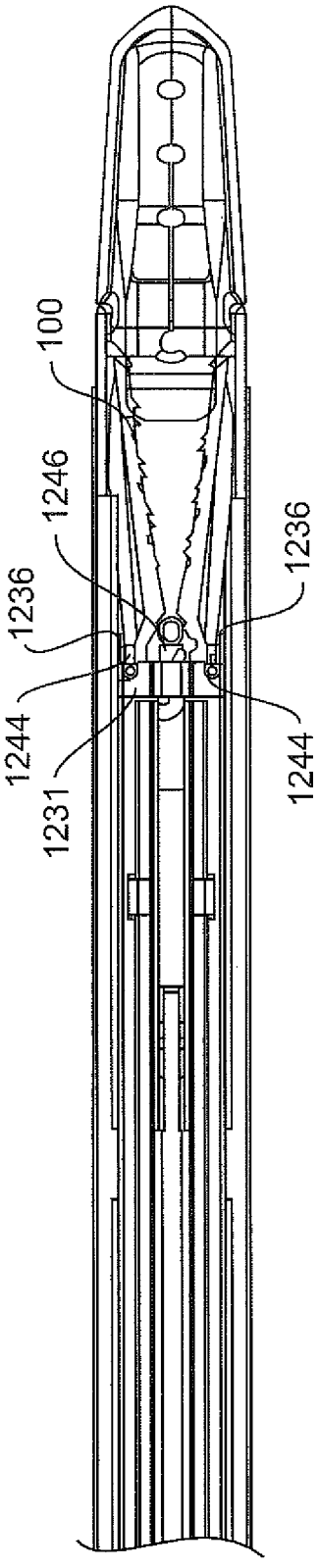

100
1246
1236
1236
1244
1231
1244

FIG. 87

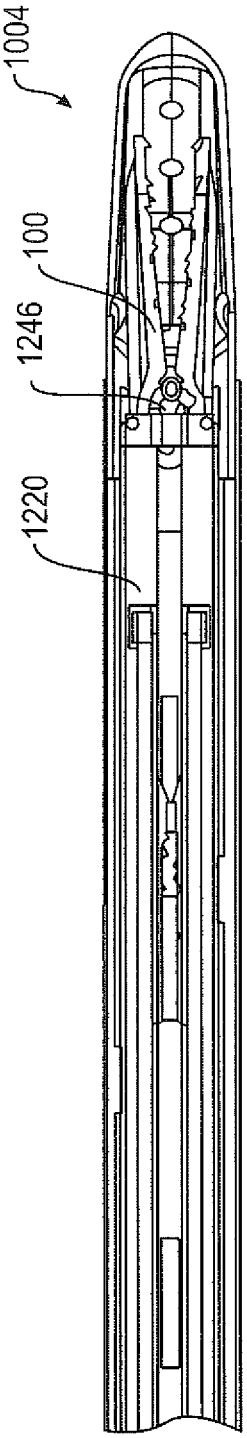


FIG. 88

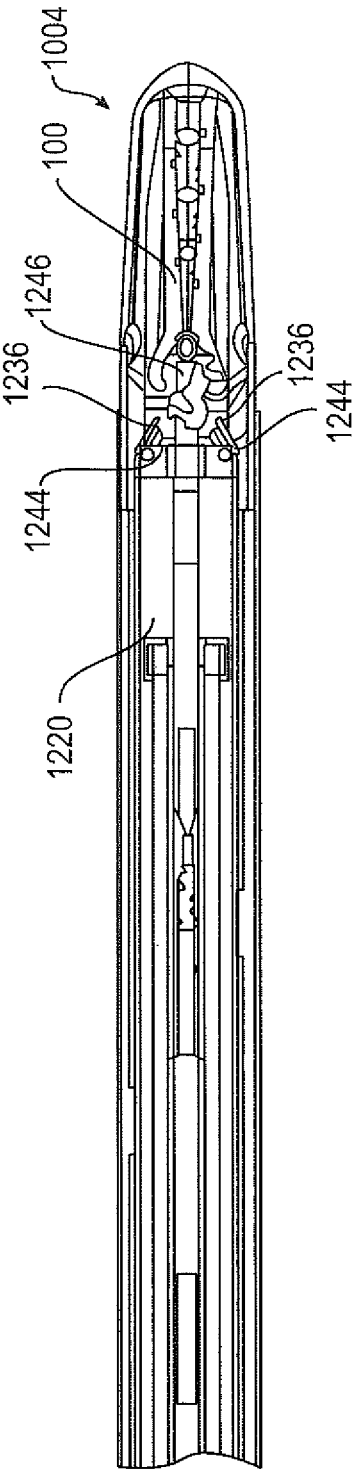


FIG. 89

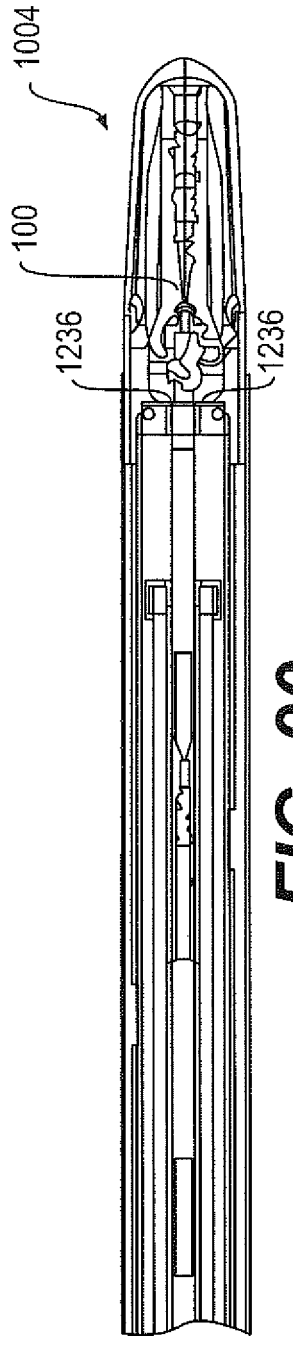


FIG. 90

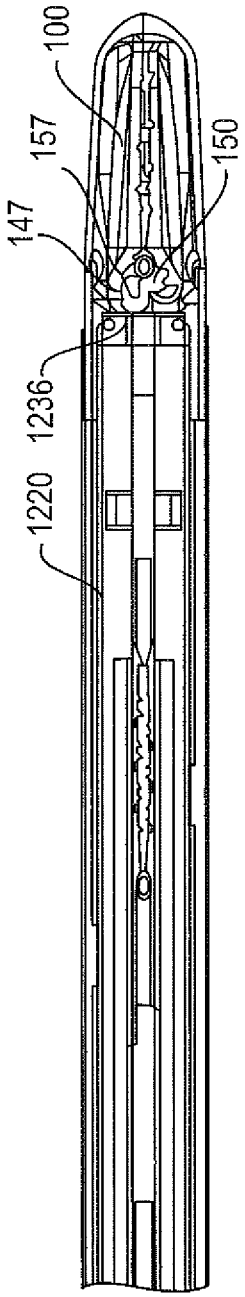


FIG. 91

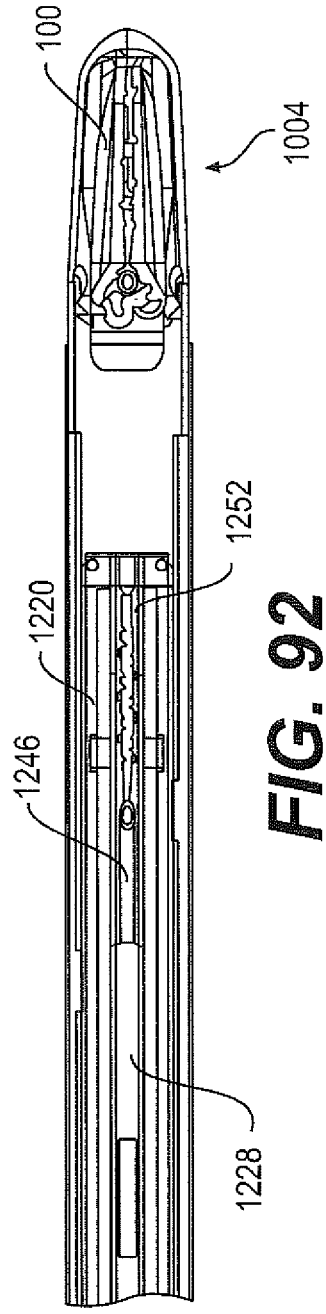


FIG. 92

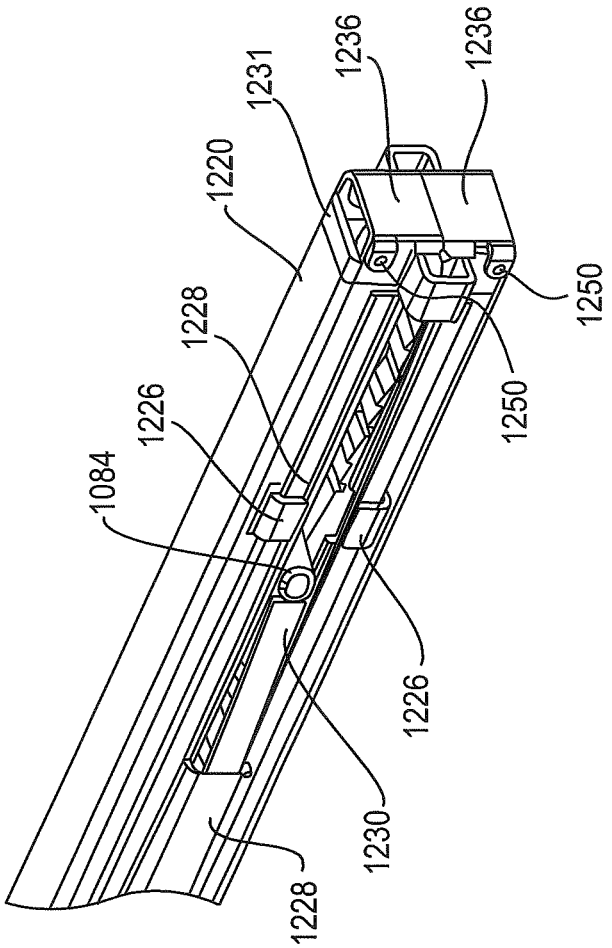


FIG. 93

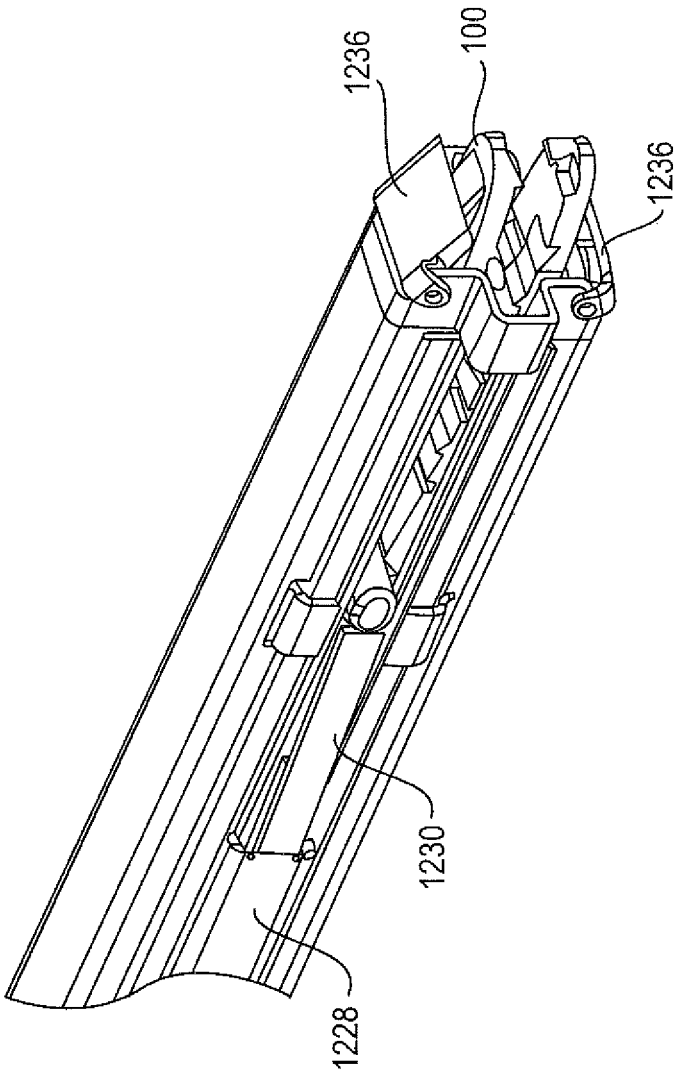


FIG. 94

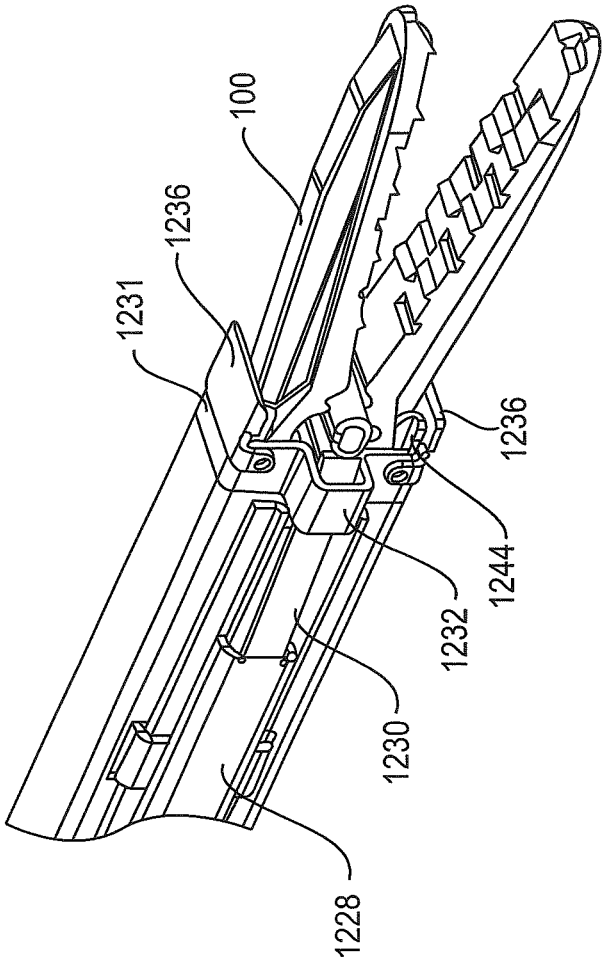


FIG. 95

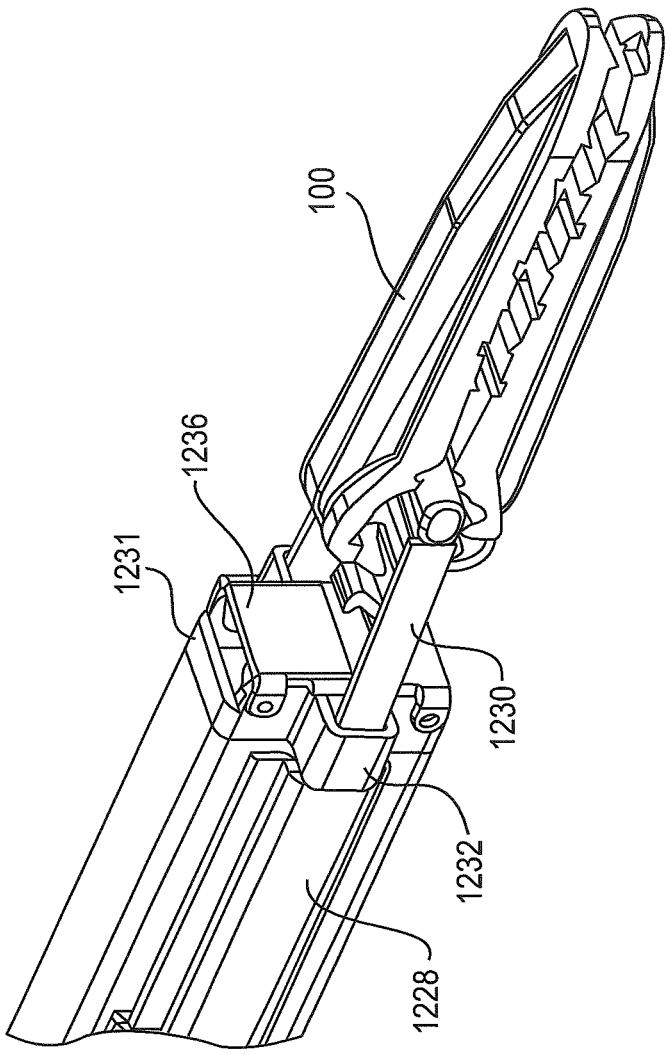


FIG. 96

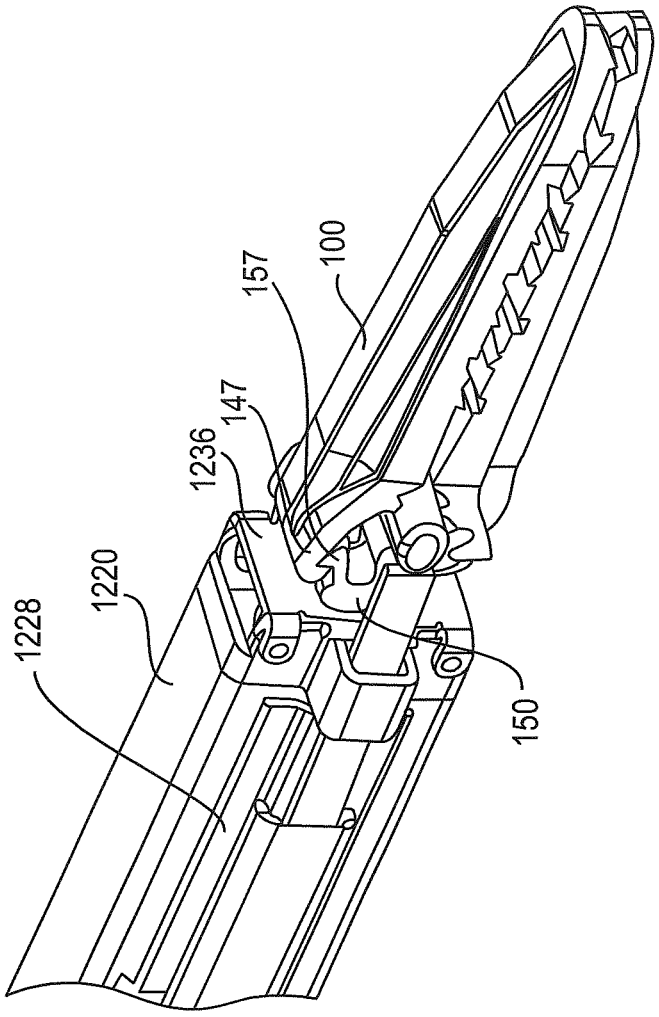


FIG. 97

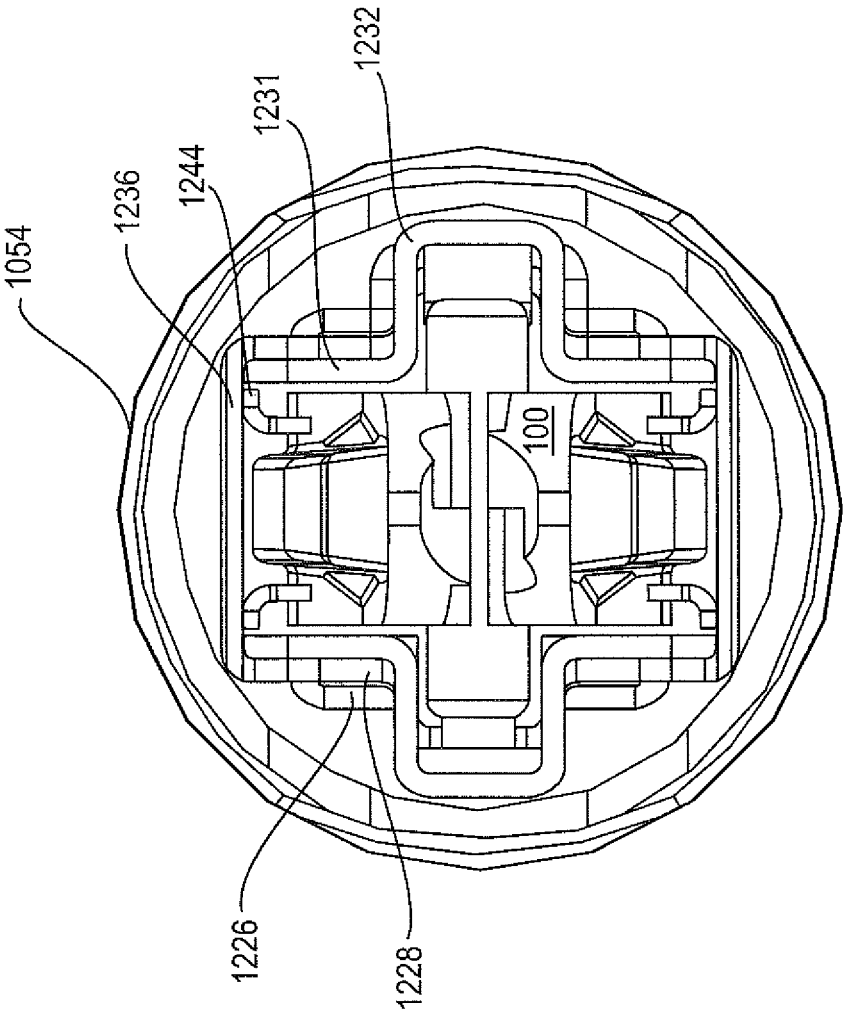


FIG. 98

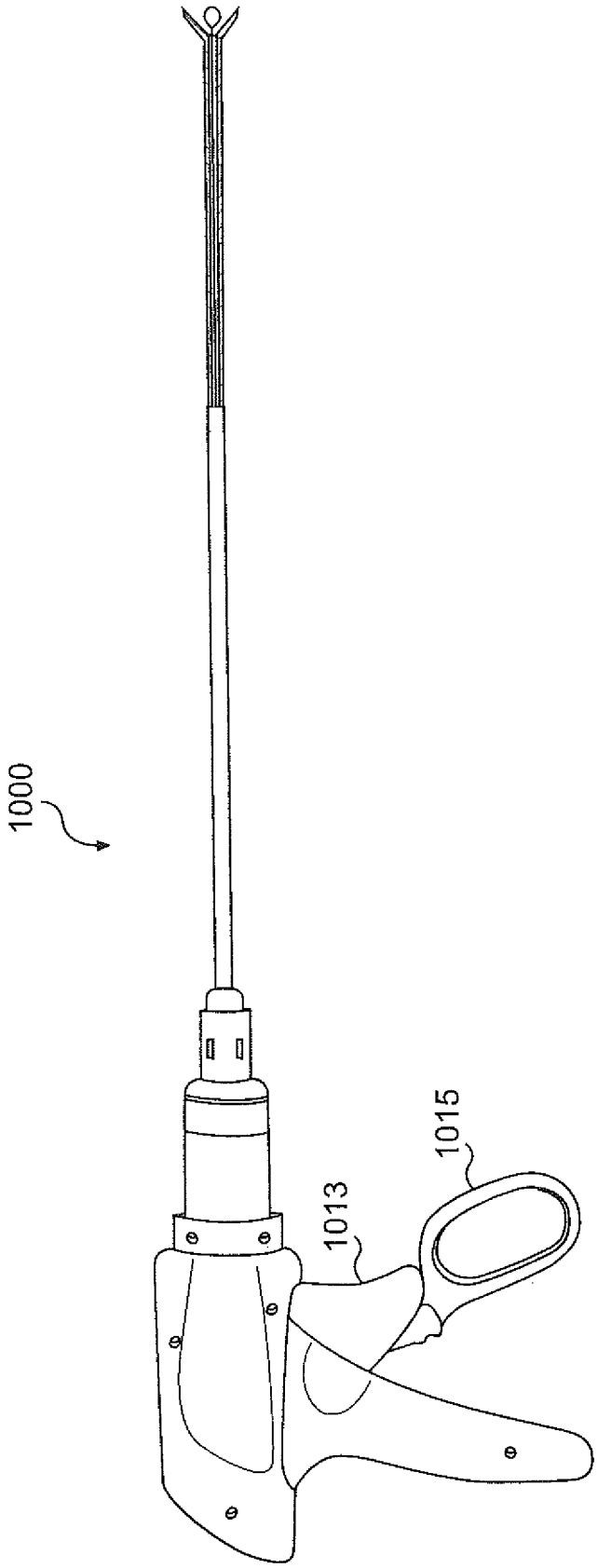


FIG. 99

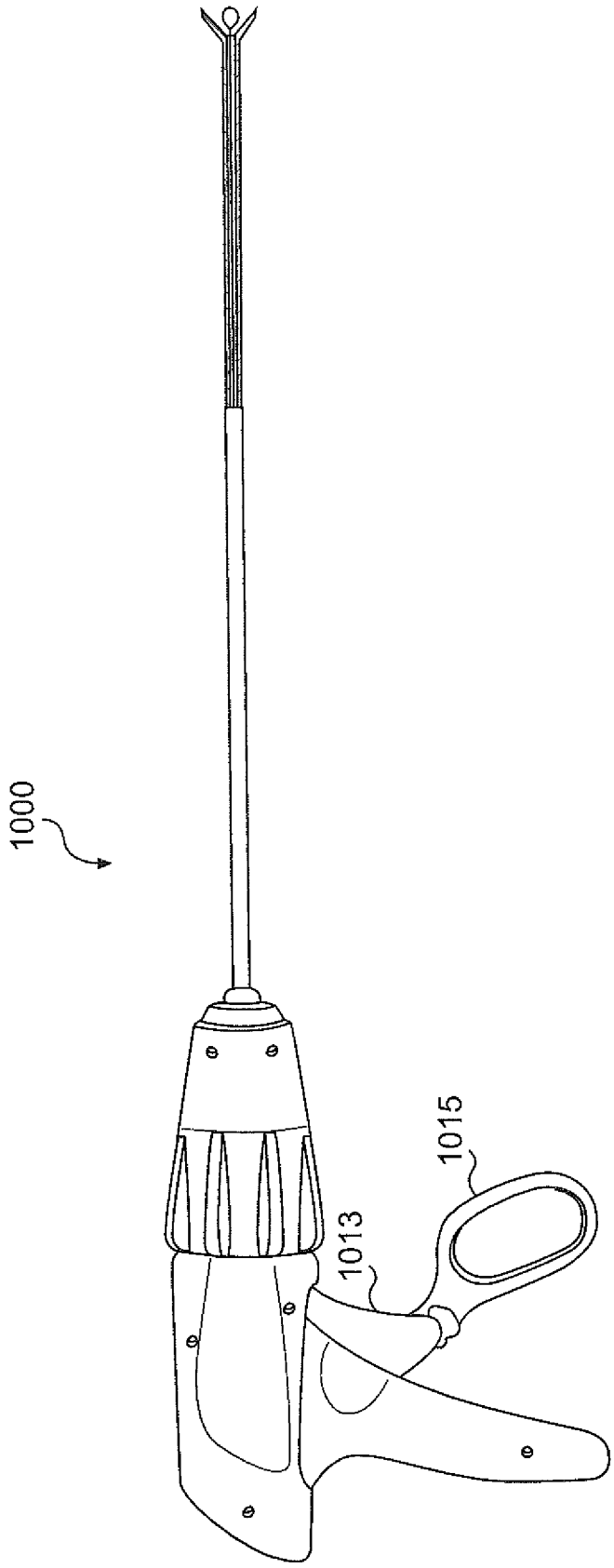


FIG. 100

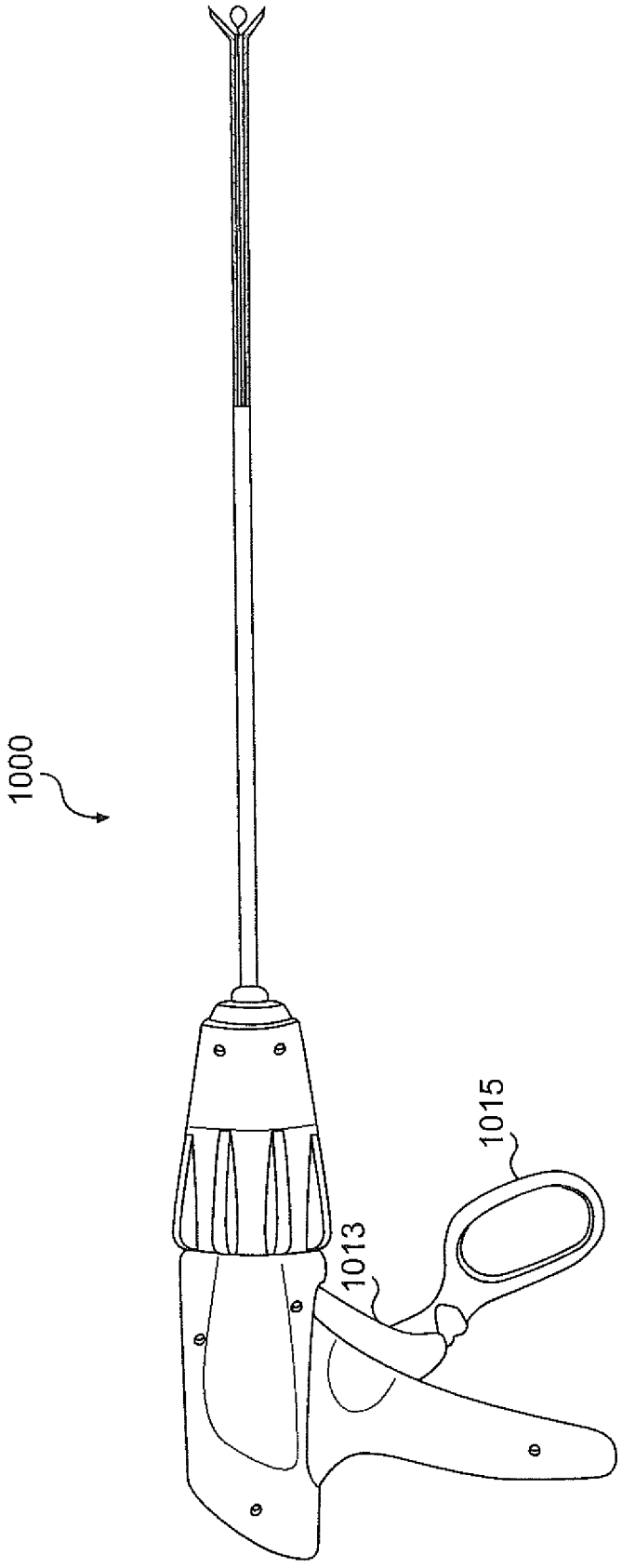


FIG. 101

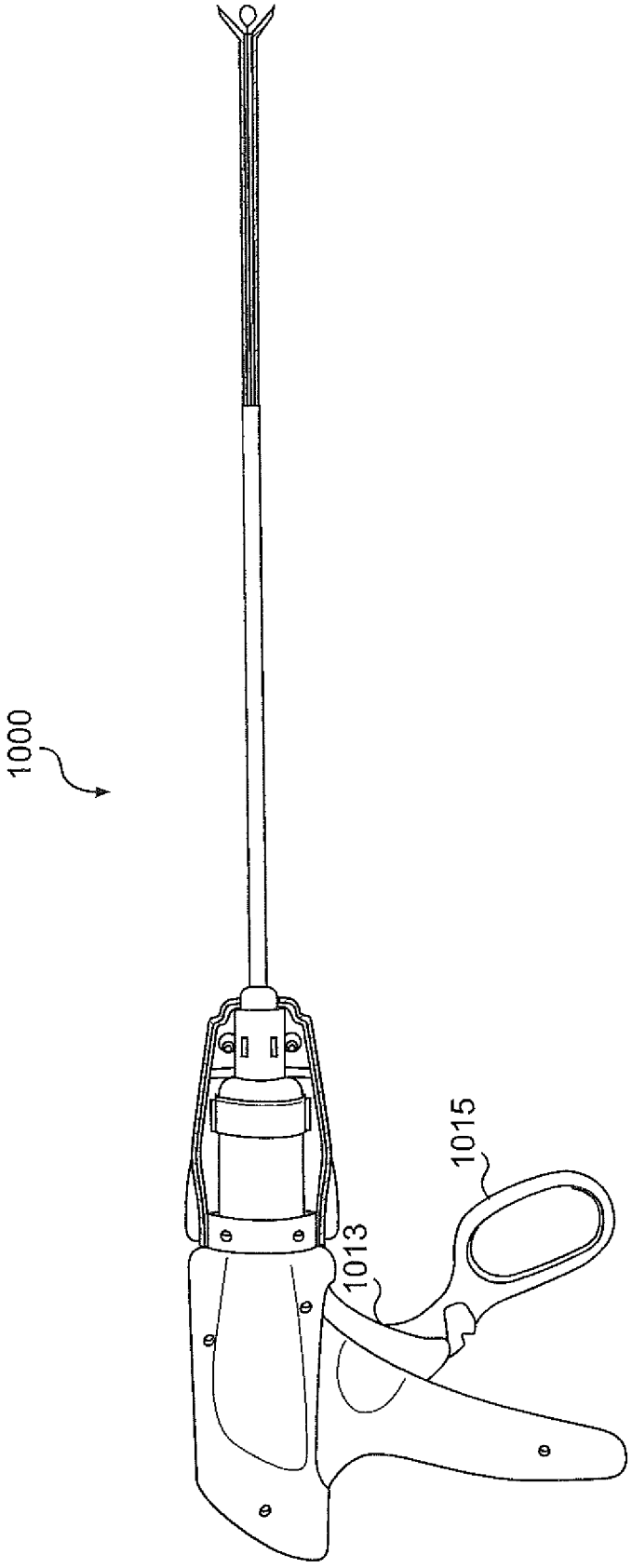


FIG. 102

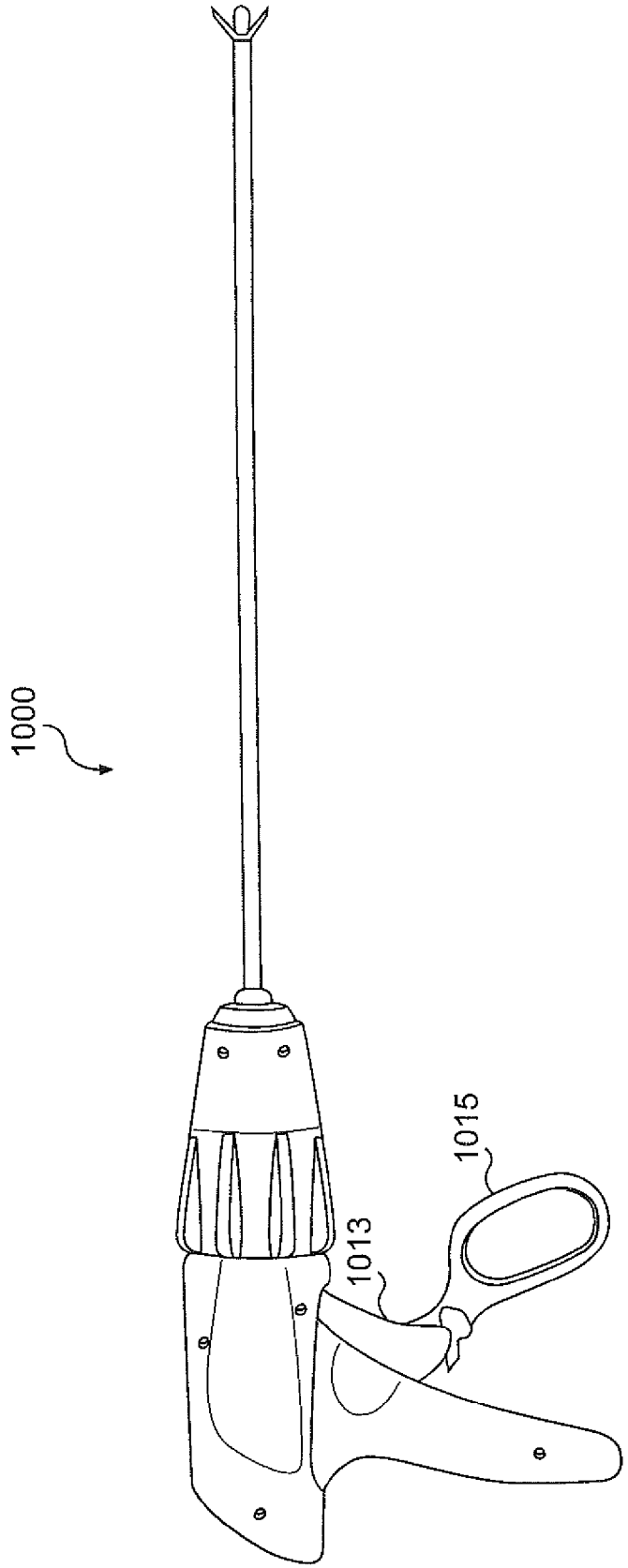


FIG. 103

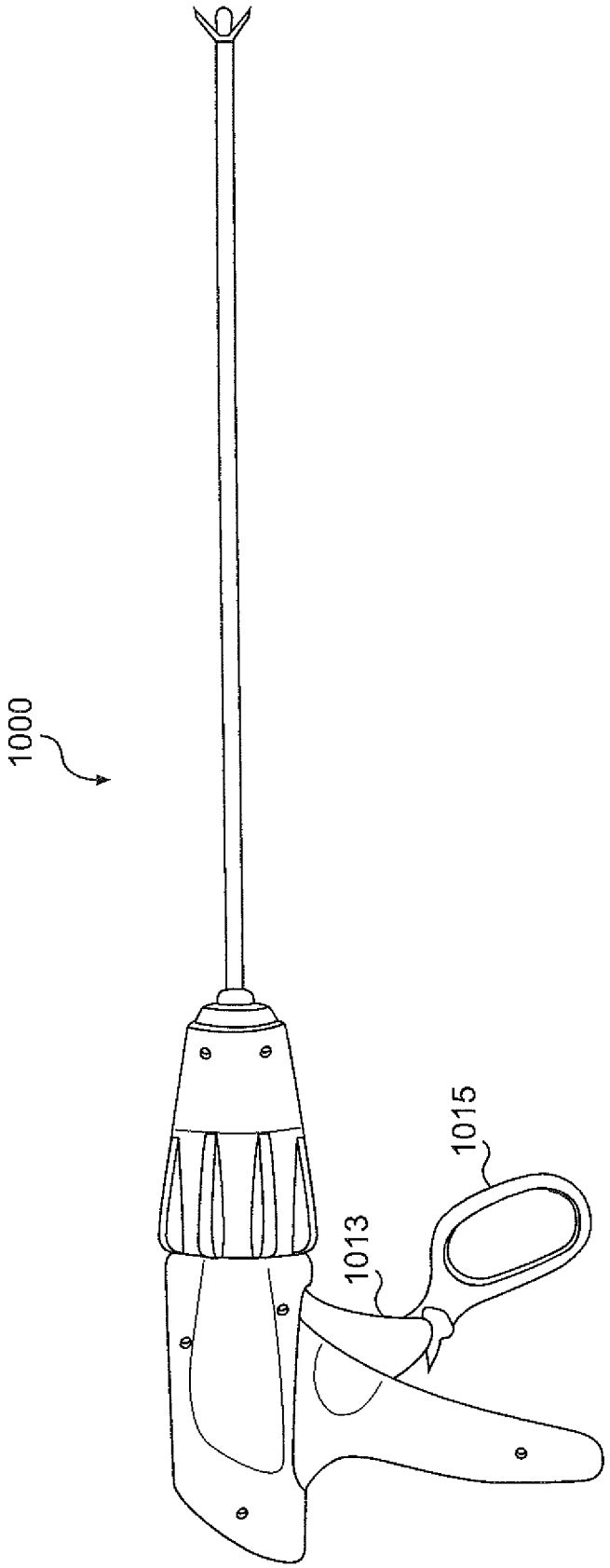


FIG. 104

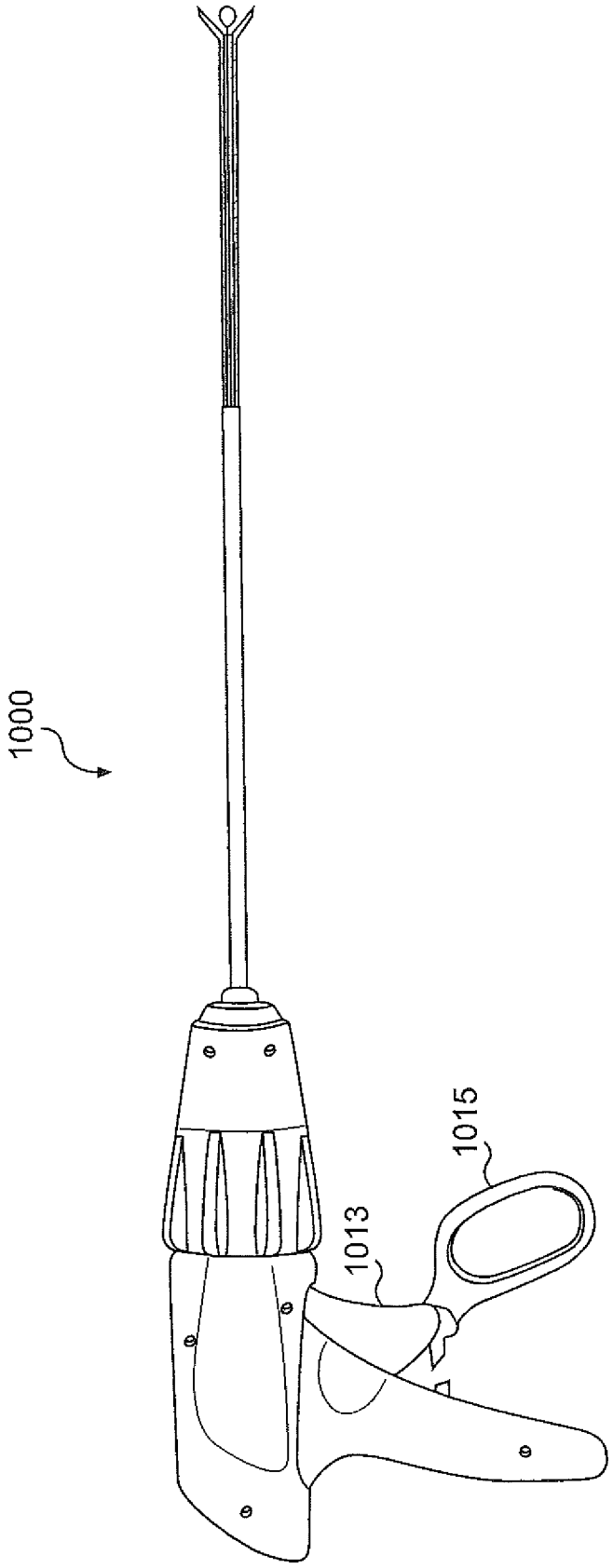


FIG. 105

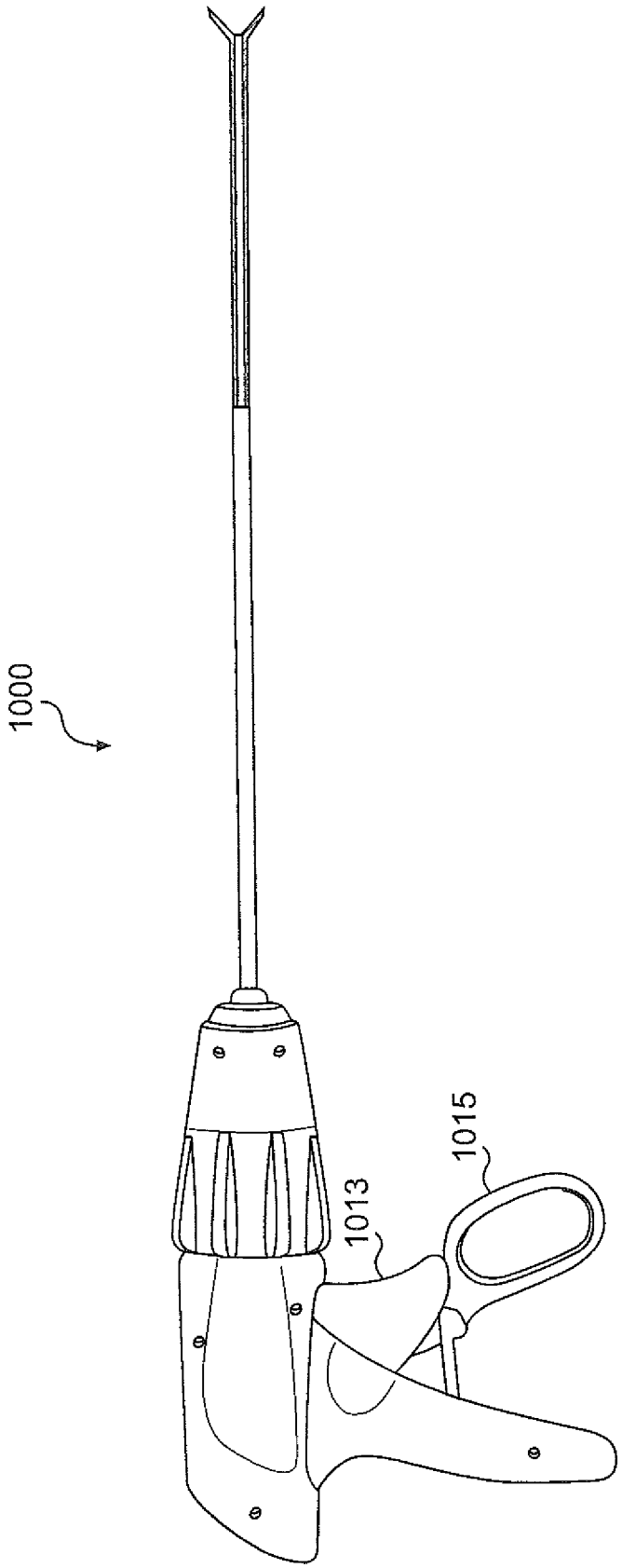


FIG. 106

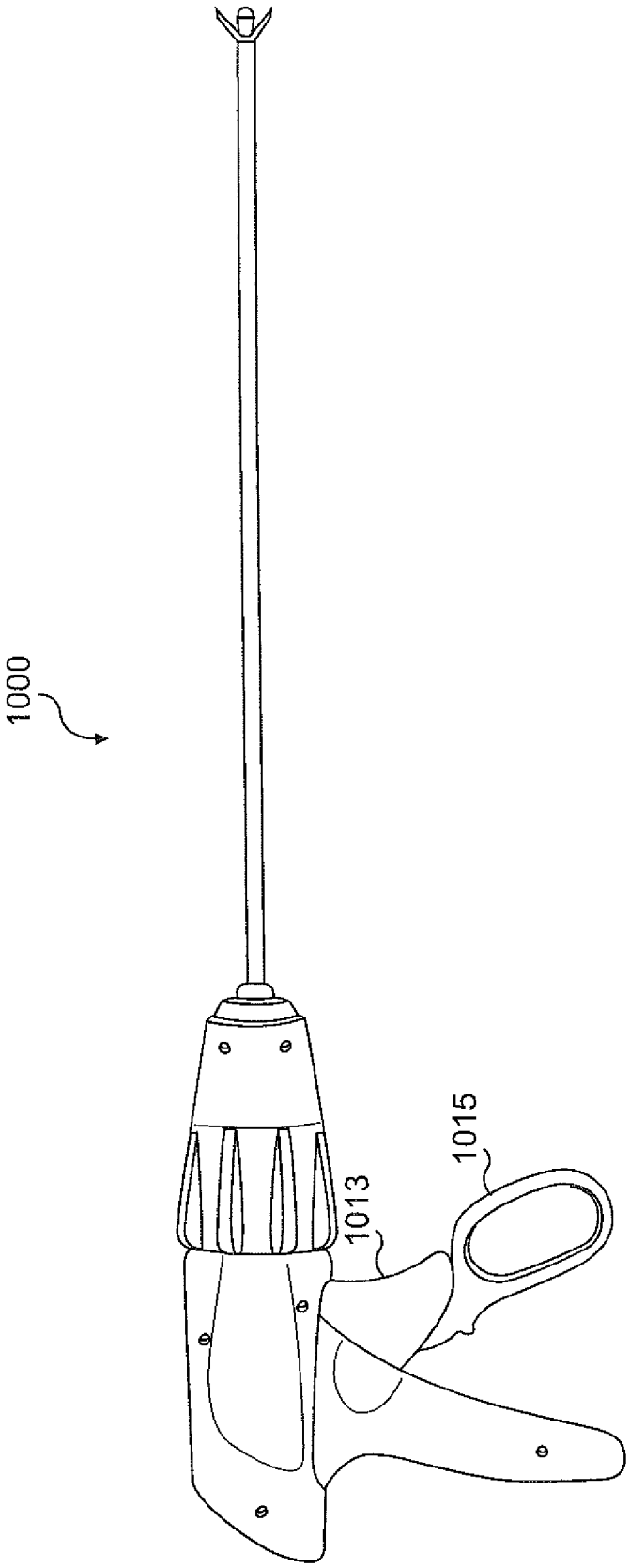


FIG. 107

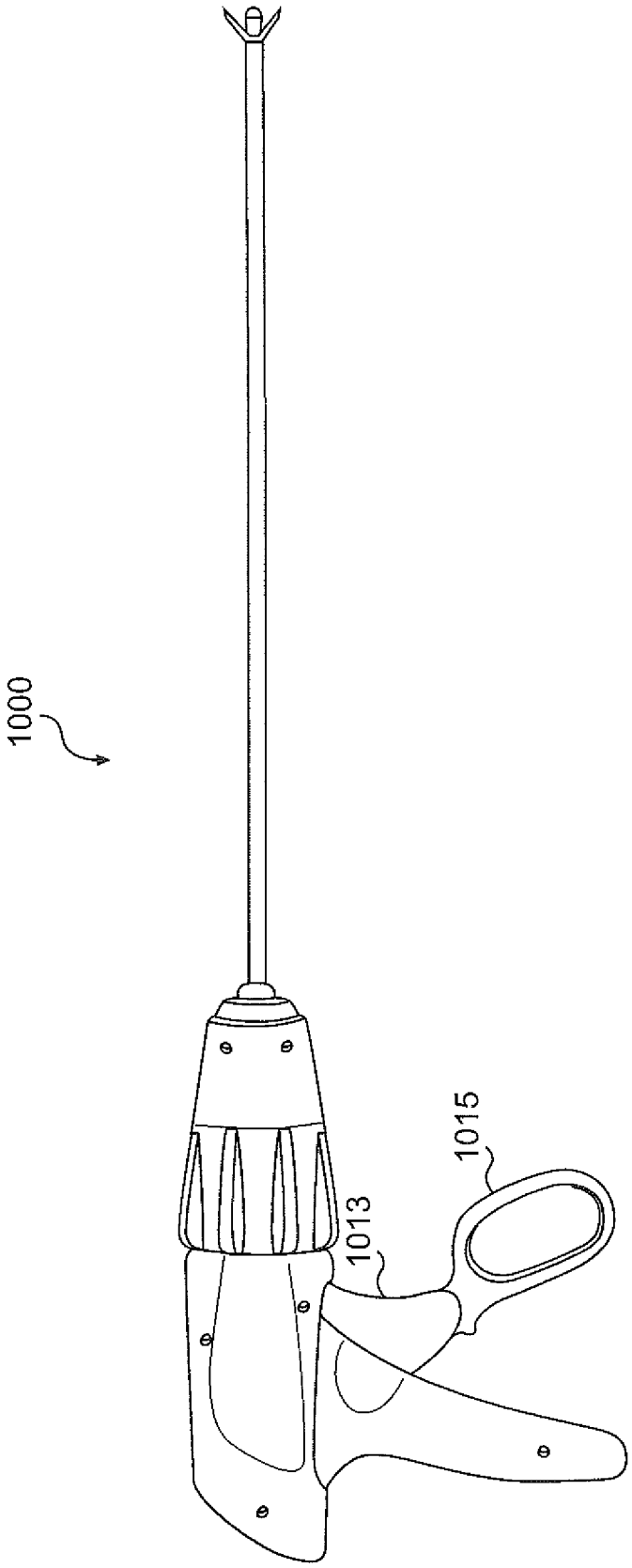


FIG. 108

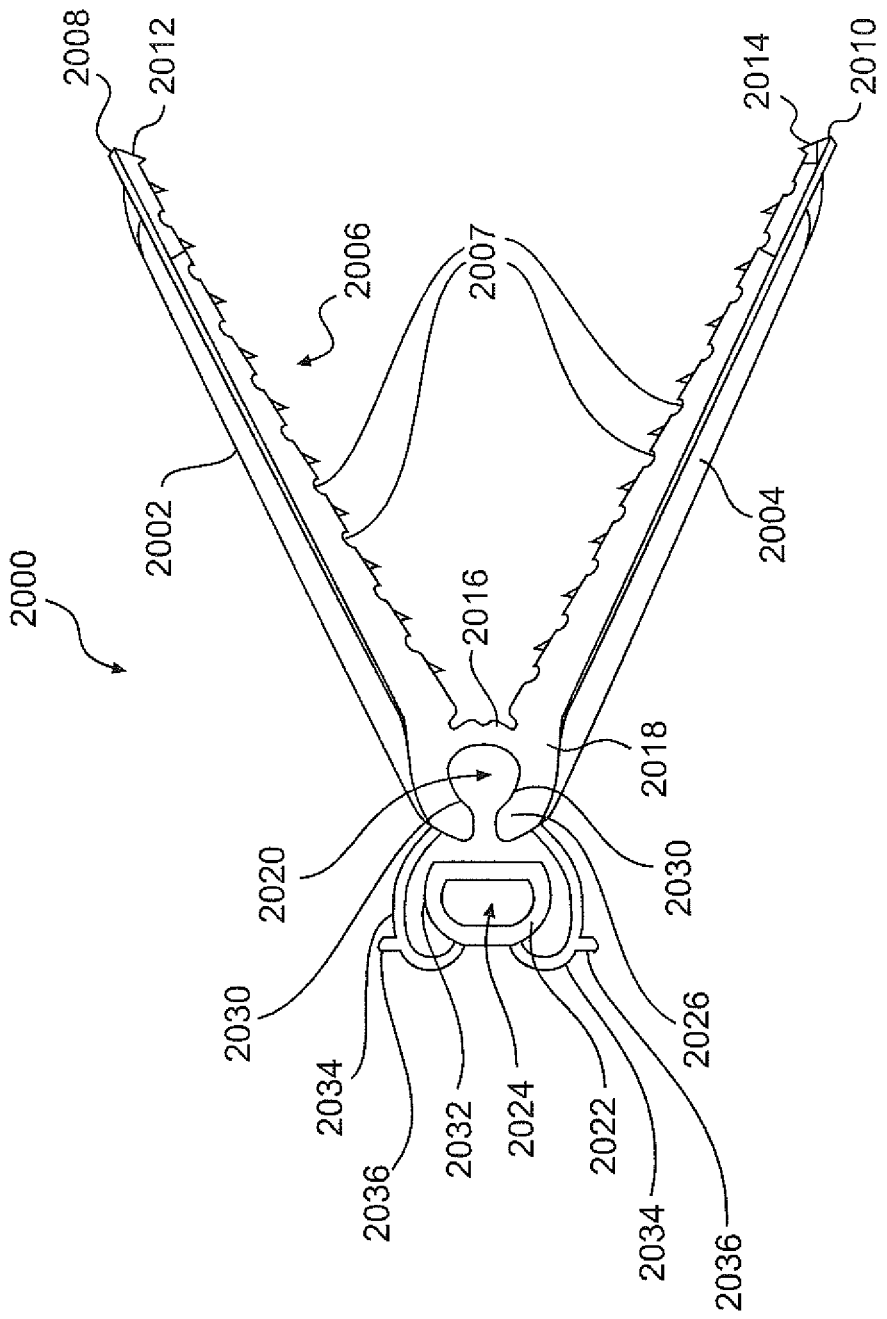

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FIG. 109

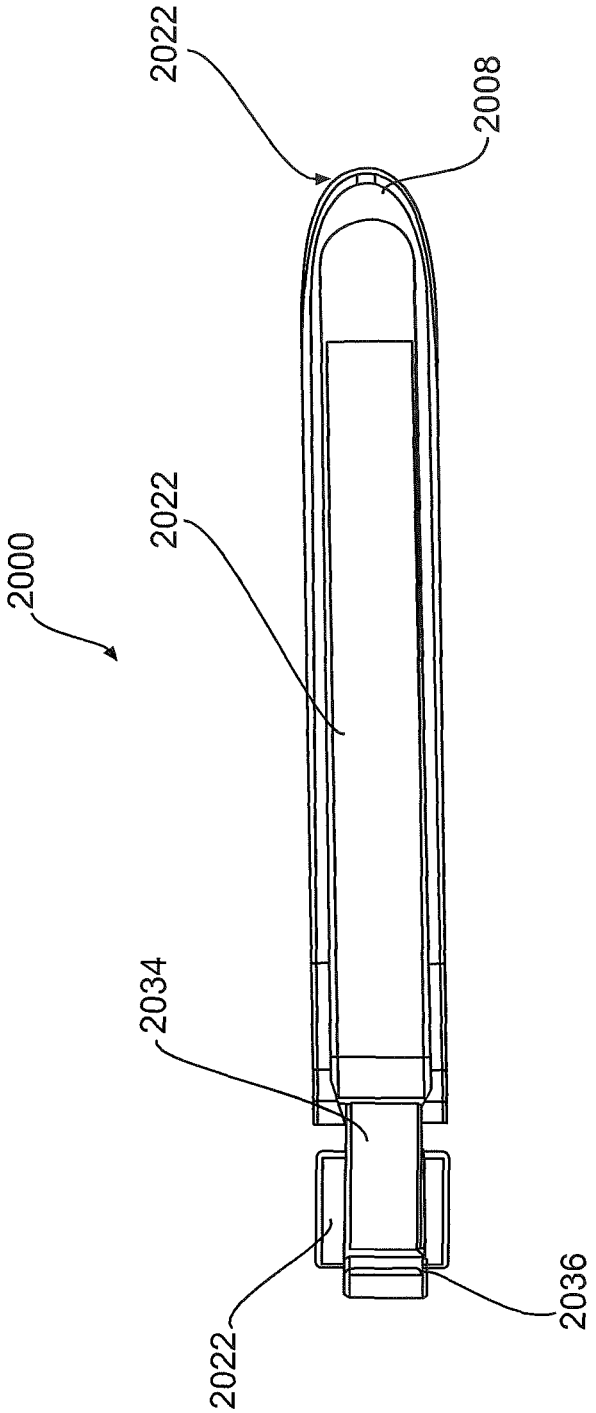


FIG. 110

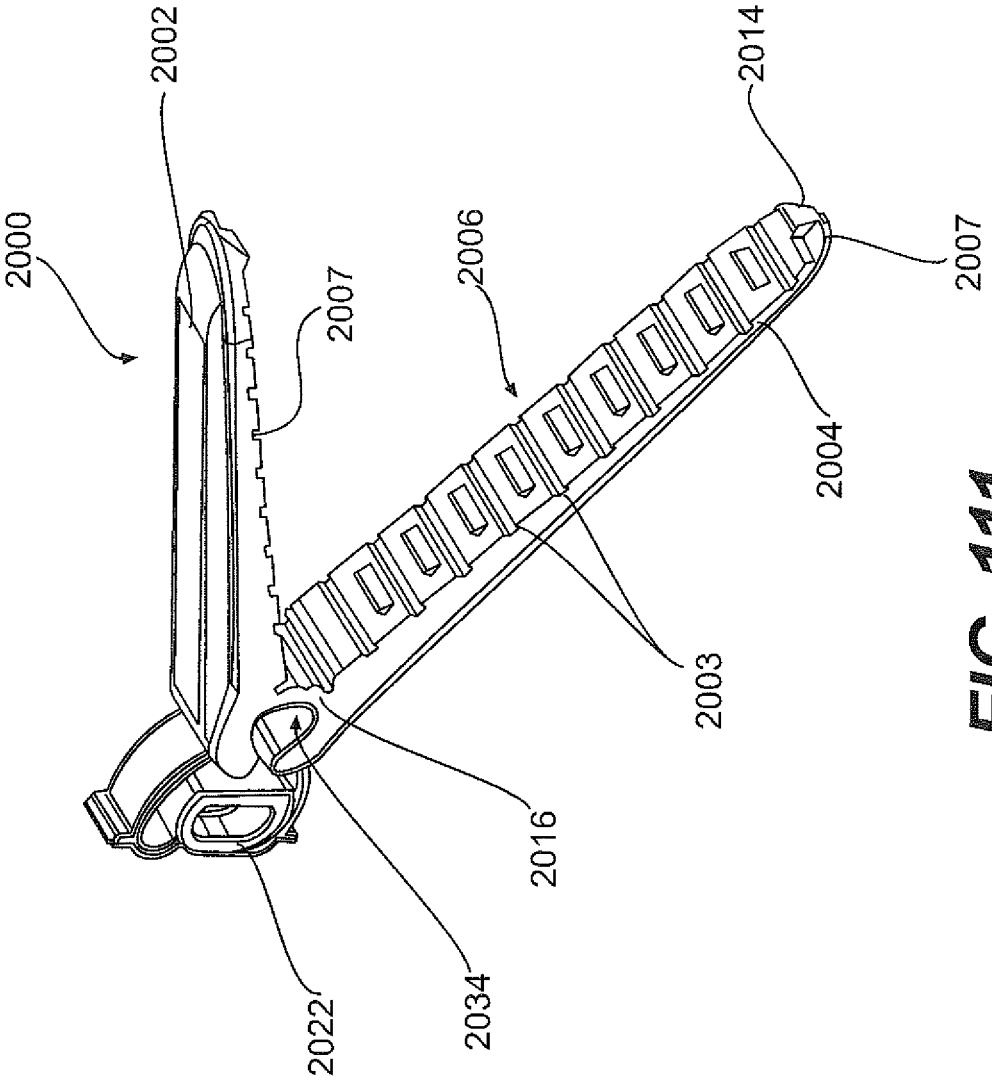


FIG. 111

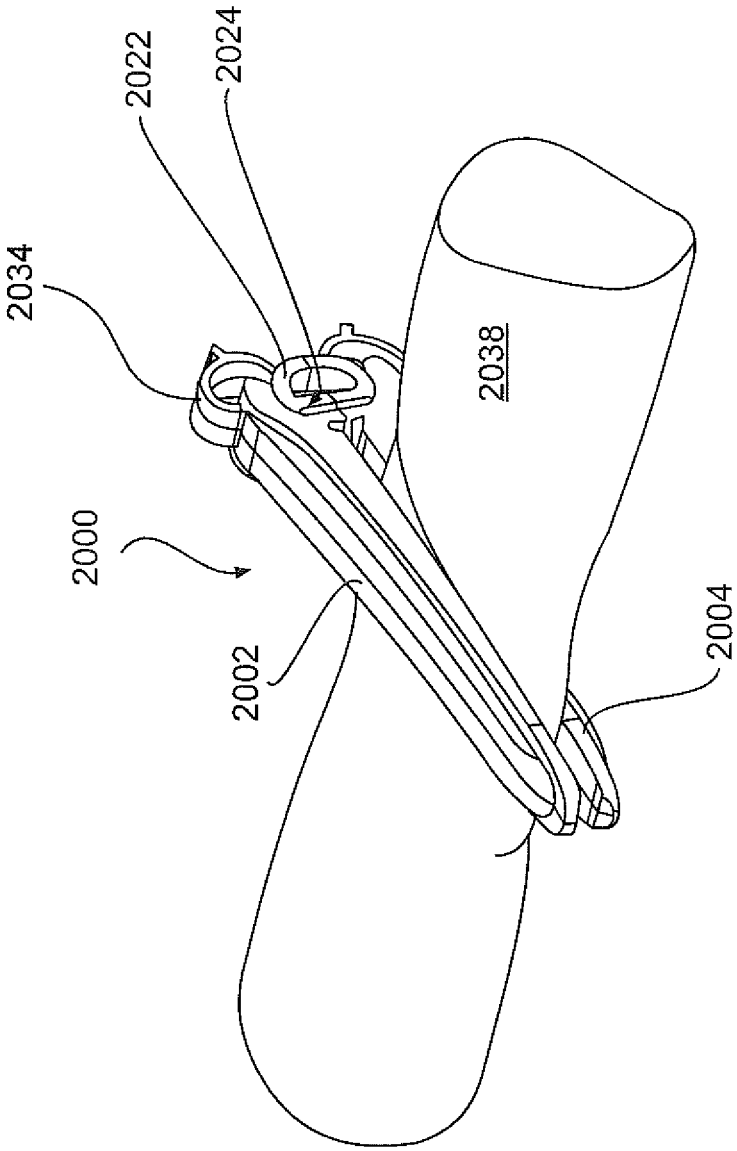


FIG. 112

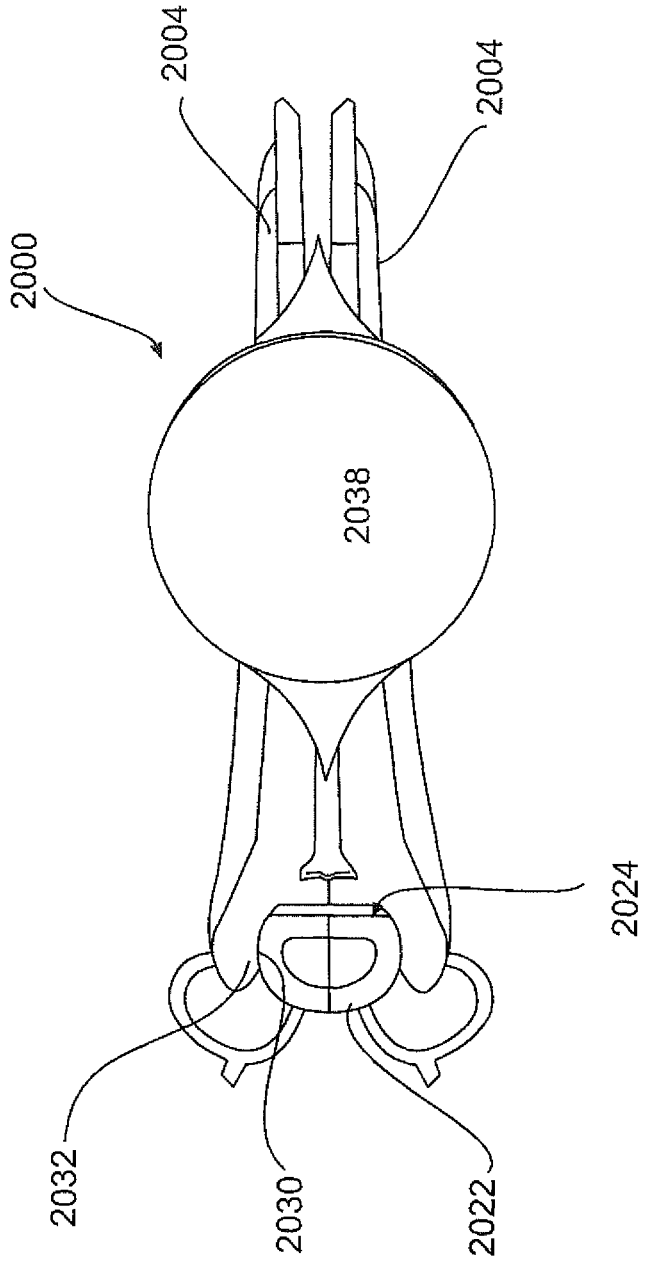


FIG. 113

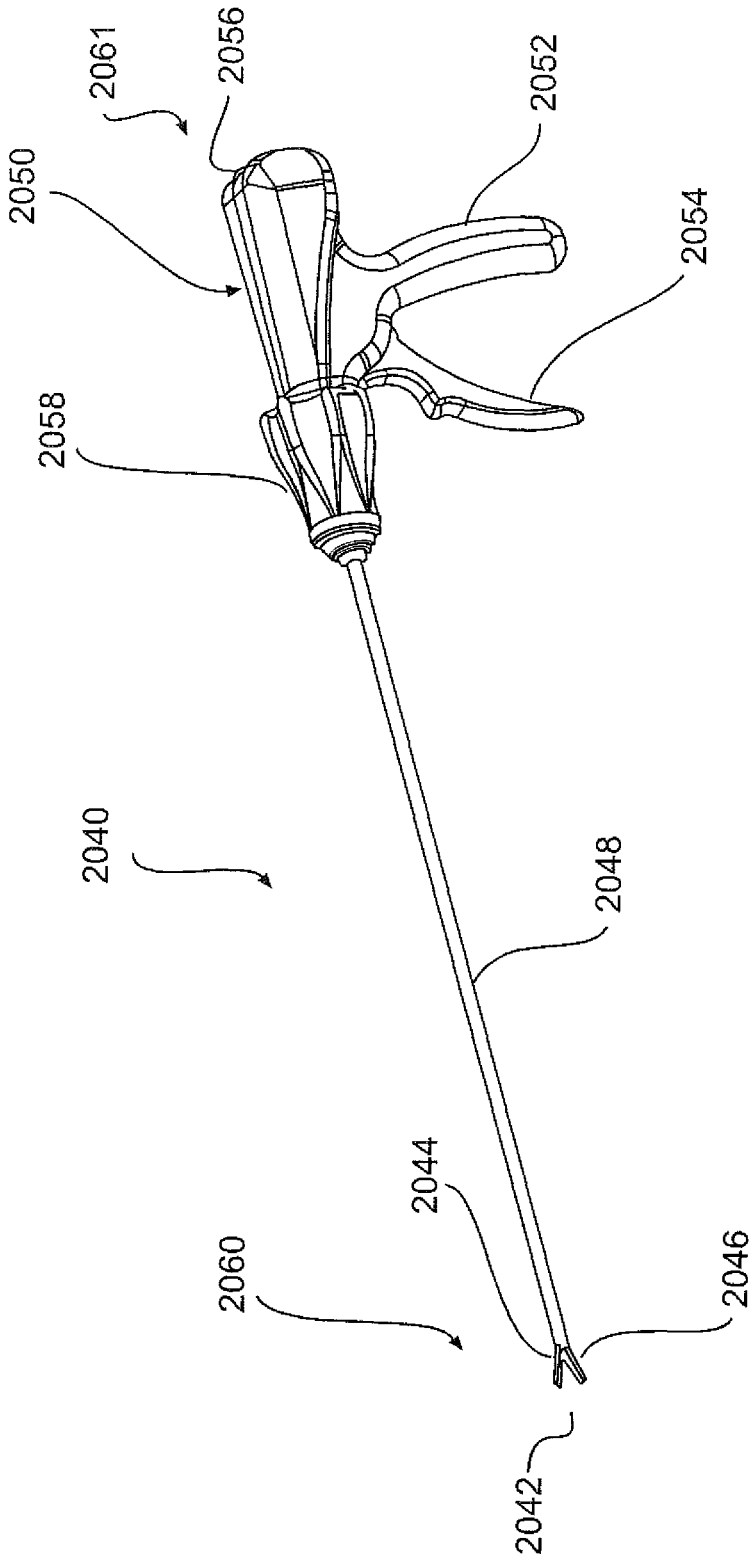


FIG. 114

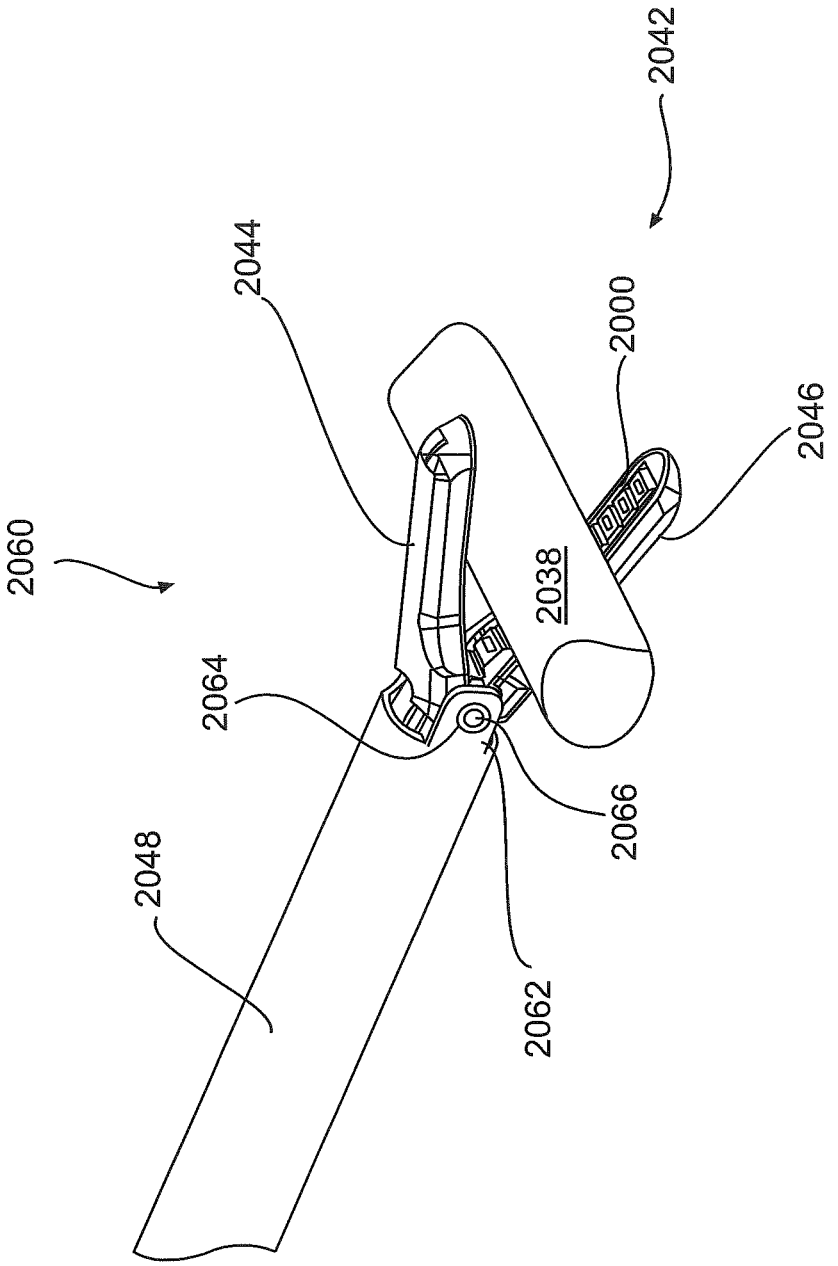


FIG. 115

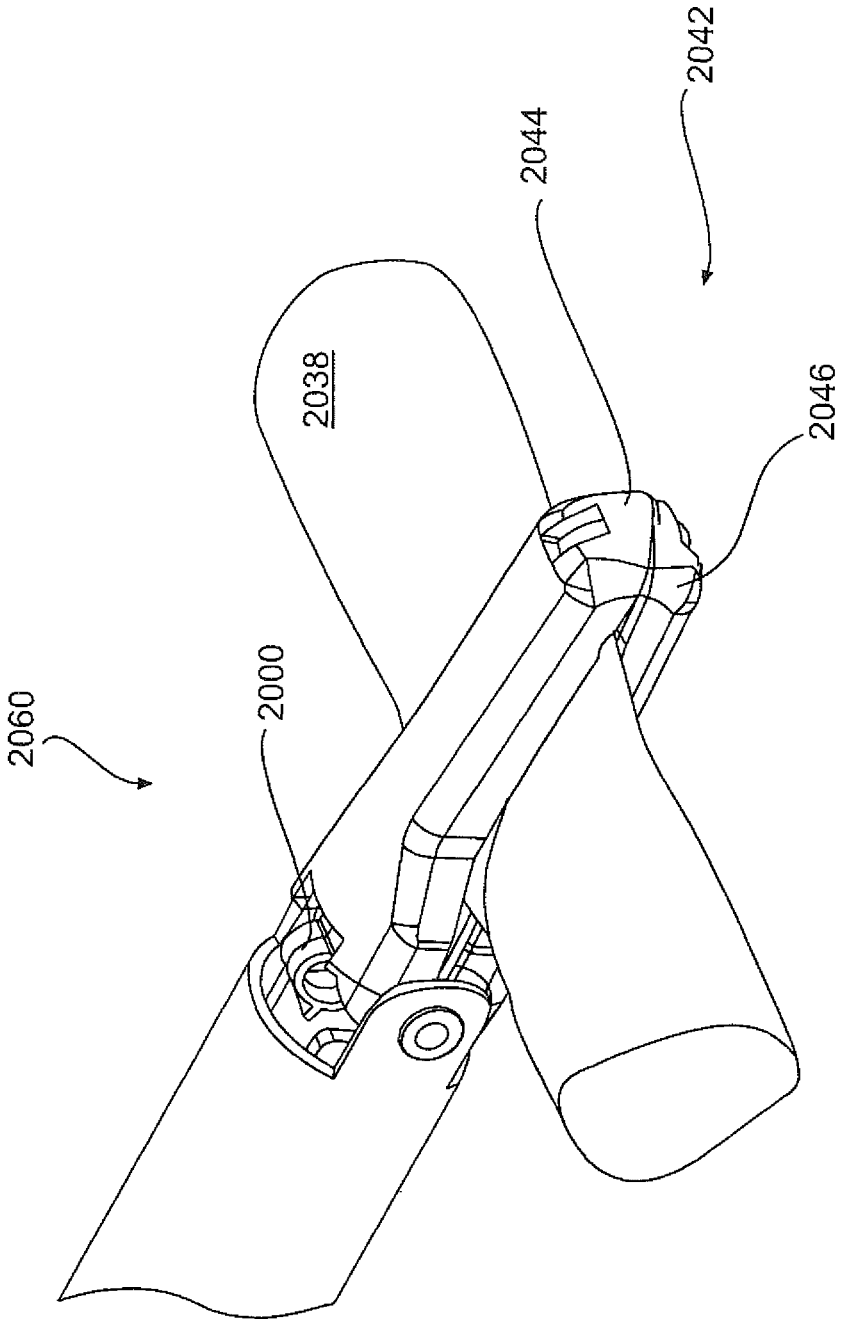
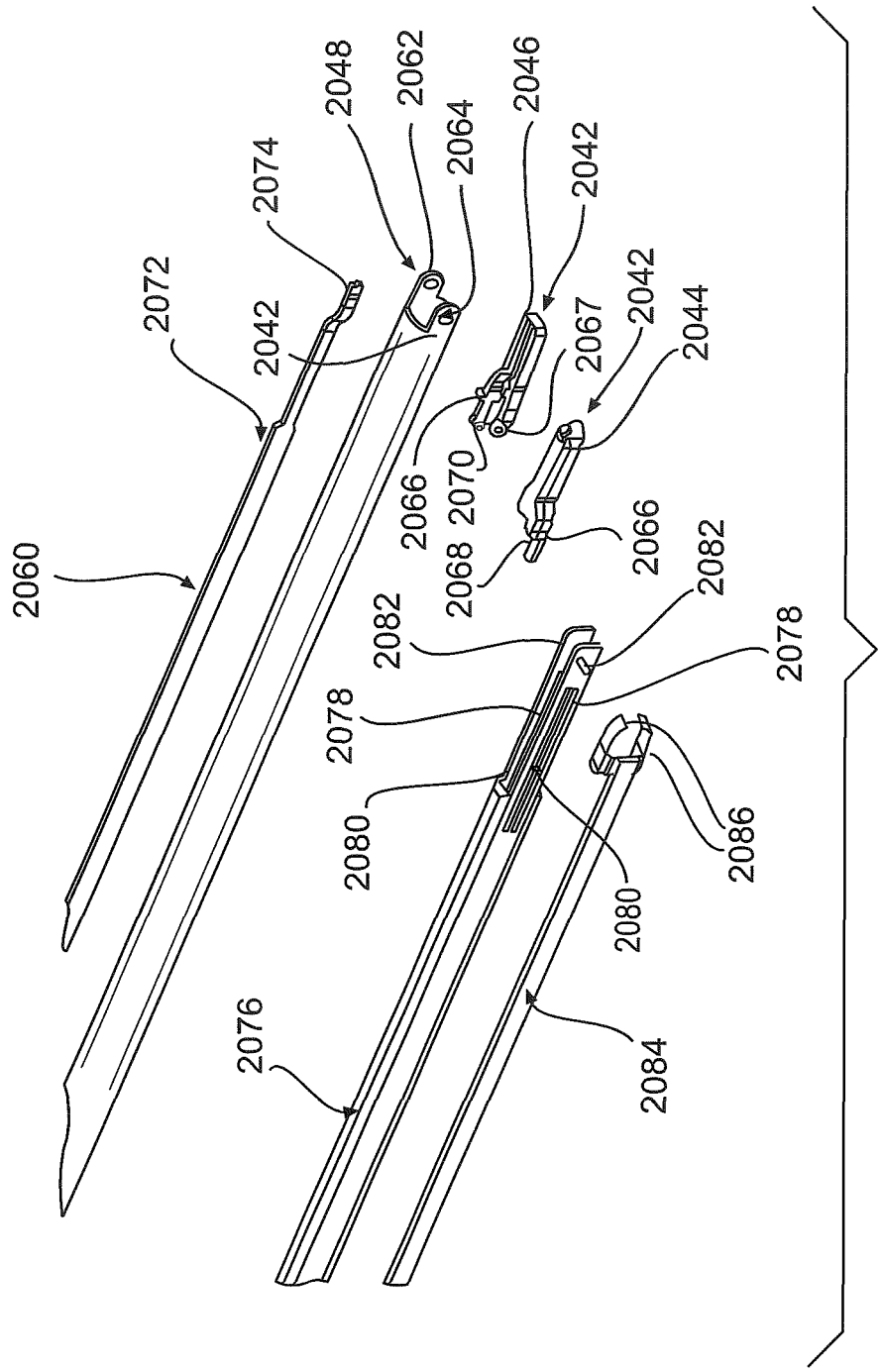


FIG. 116


2060
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2084

FIG. 117

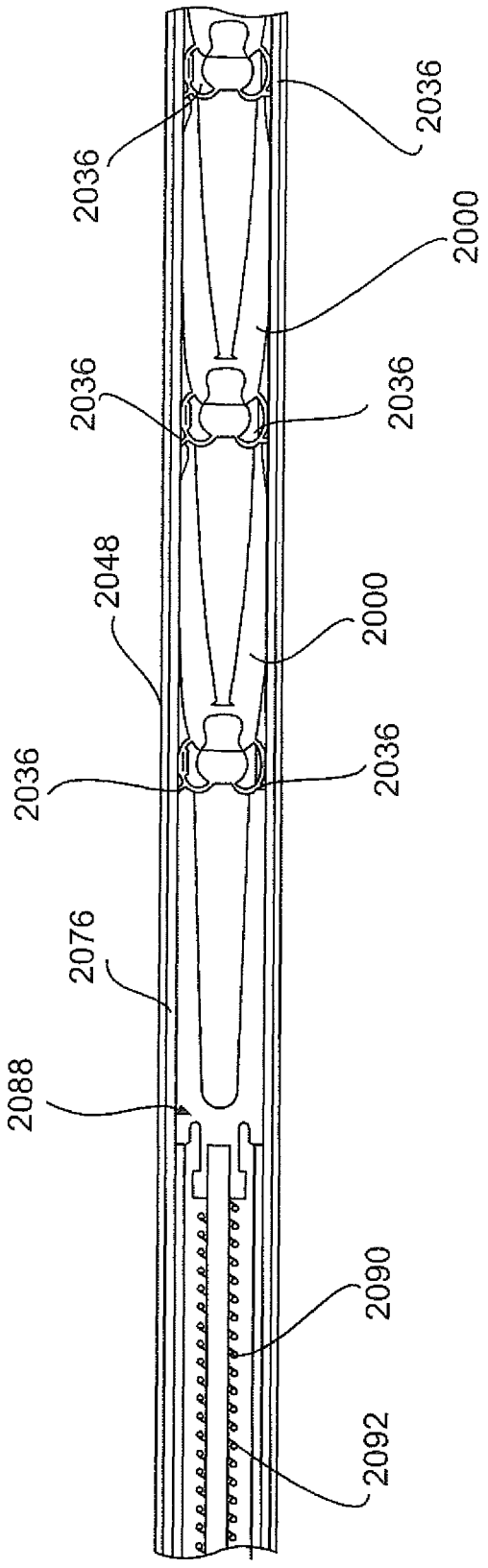

2036
2036
2000
2036
2036
2048
2000
2036
2036
2076
2088
2090
2092

FIG. 118

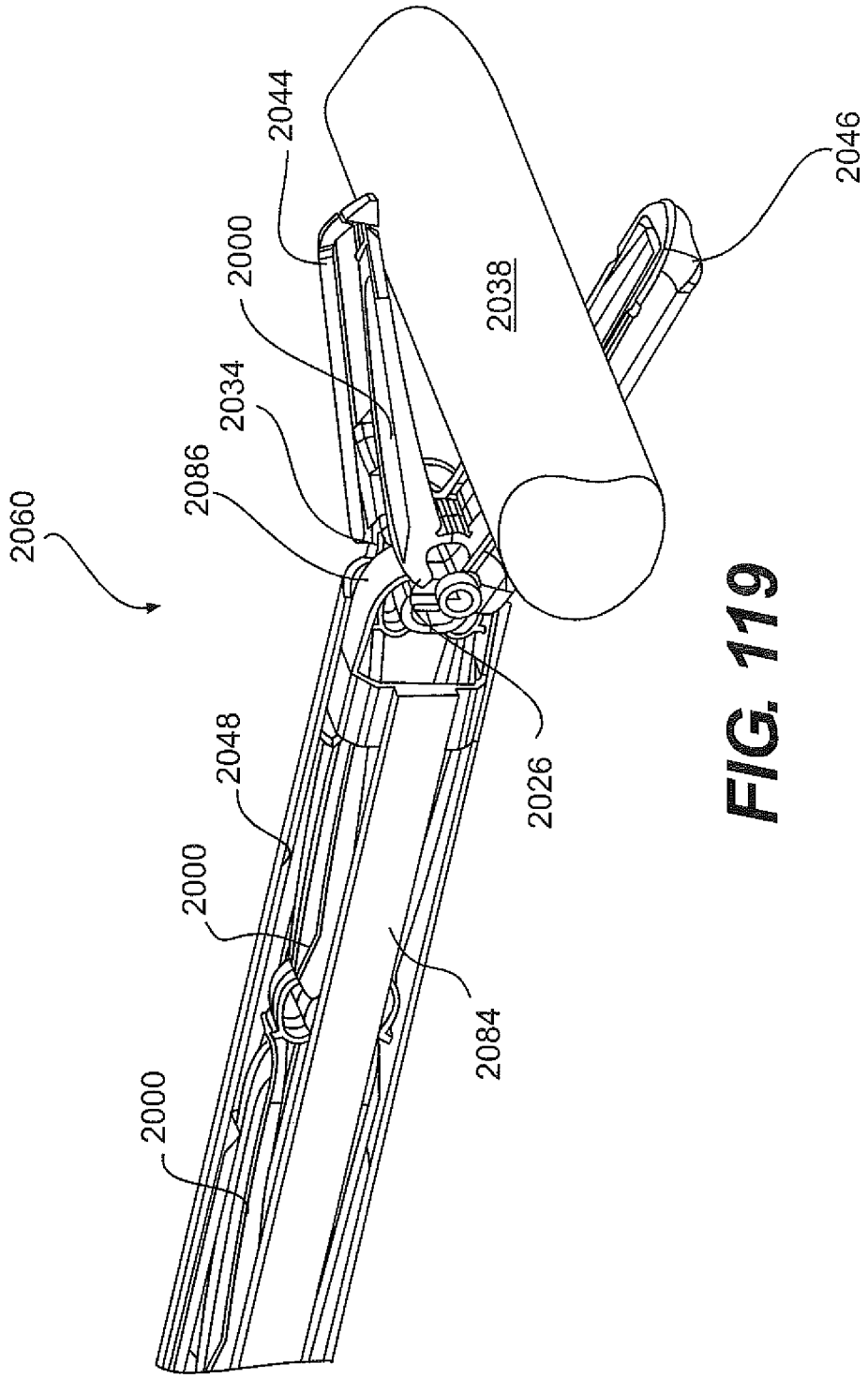


FIG. 119

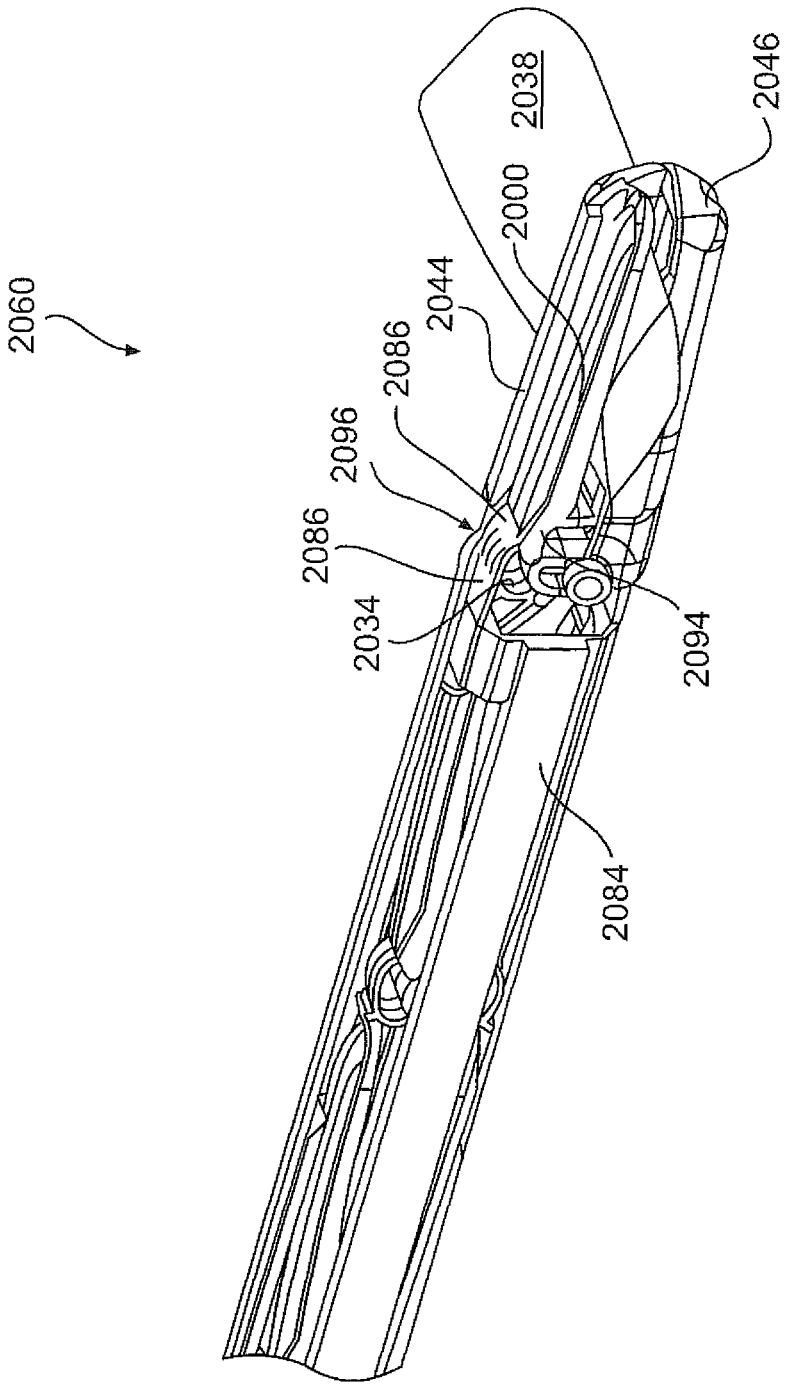


FIG. 120

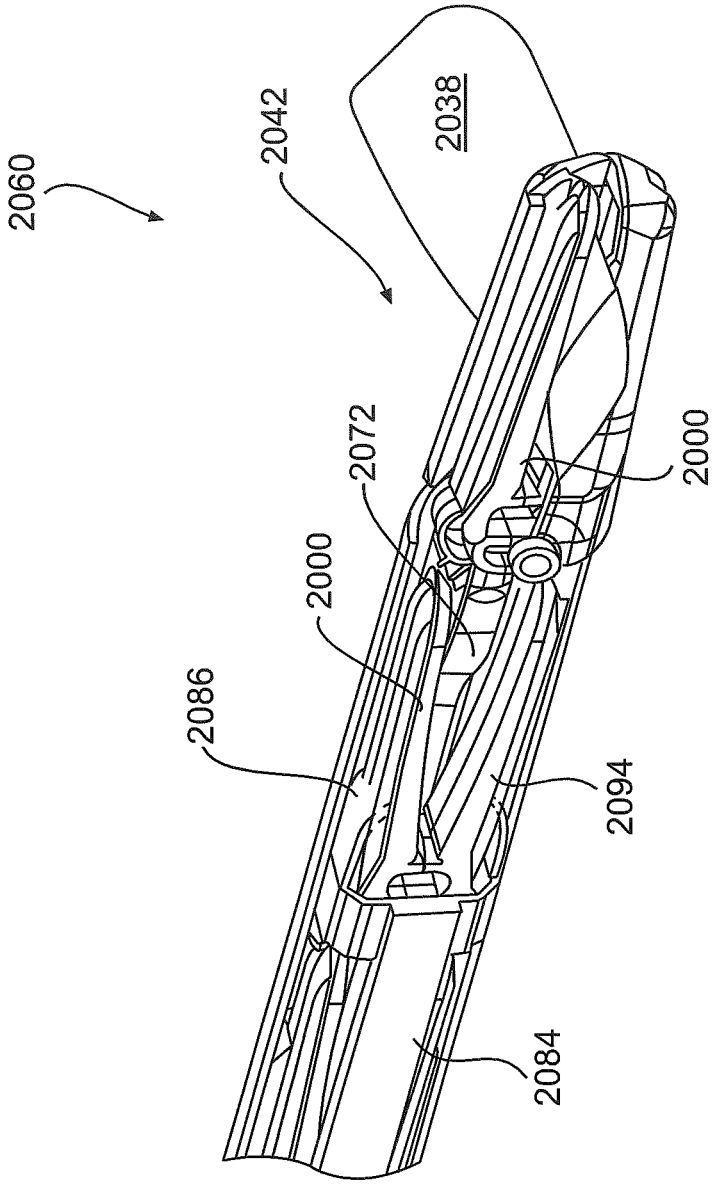


FIG. 121

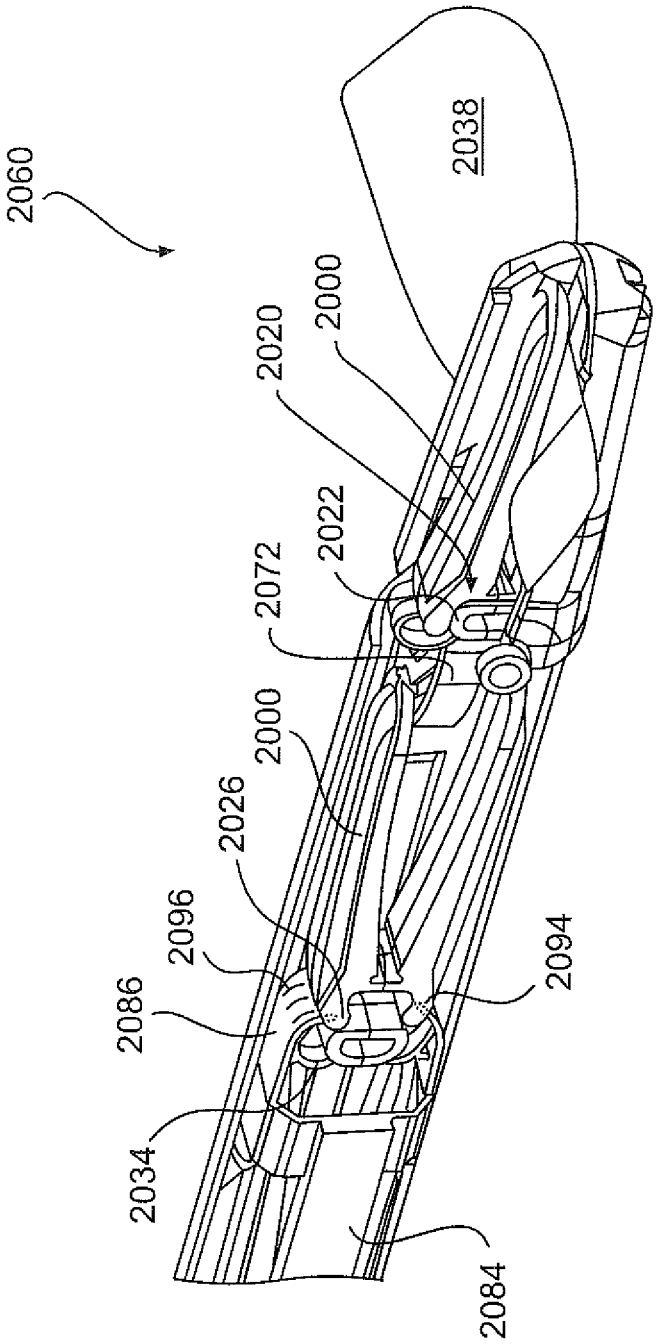
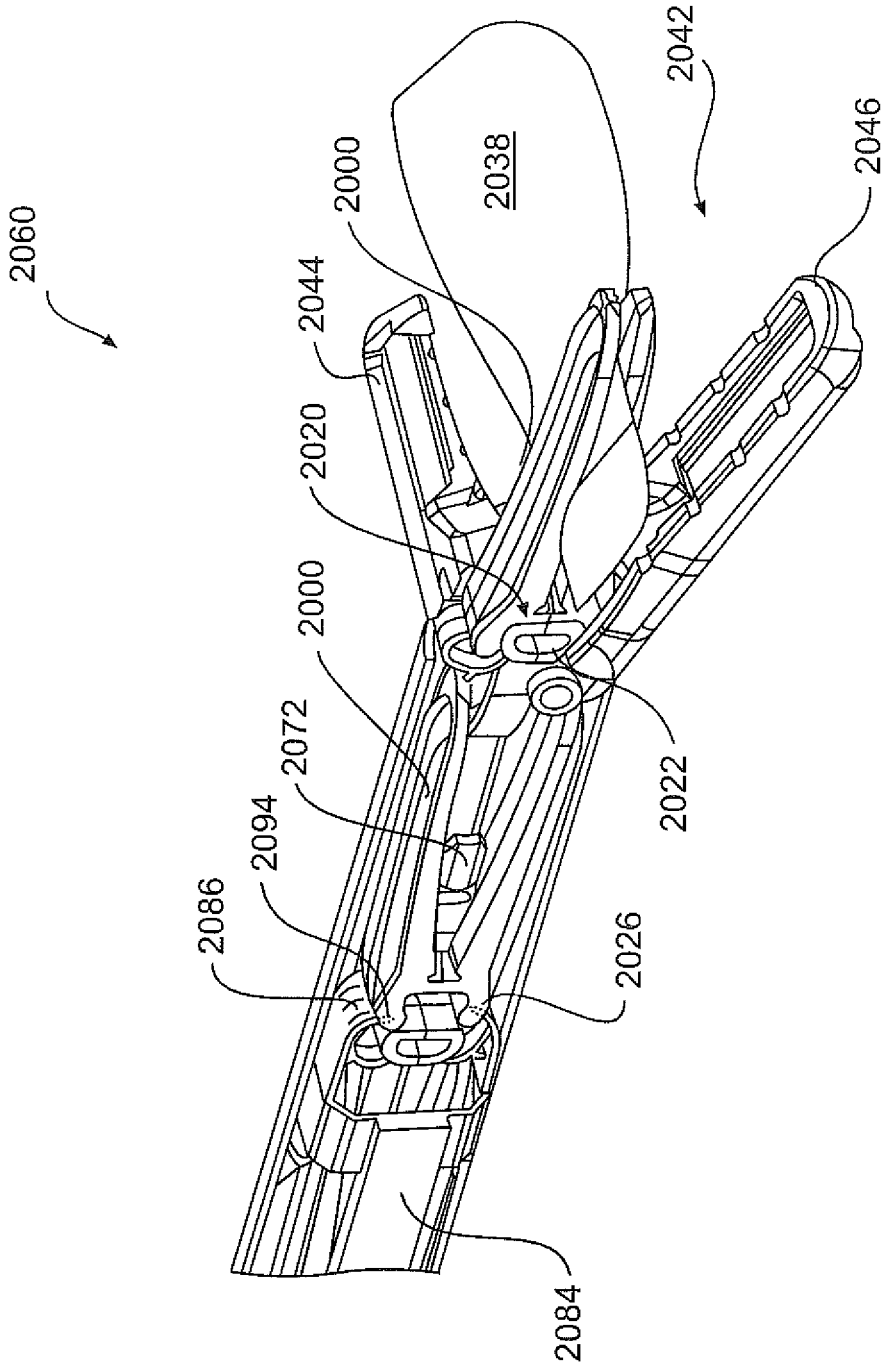

2060
2038
2000
2020
2022
2072
2000
2026
2096
2086
2094
2034
2084

FIG. 122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2026
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FIG. 123

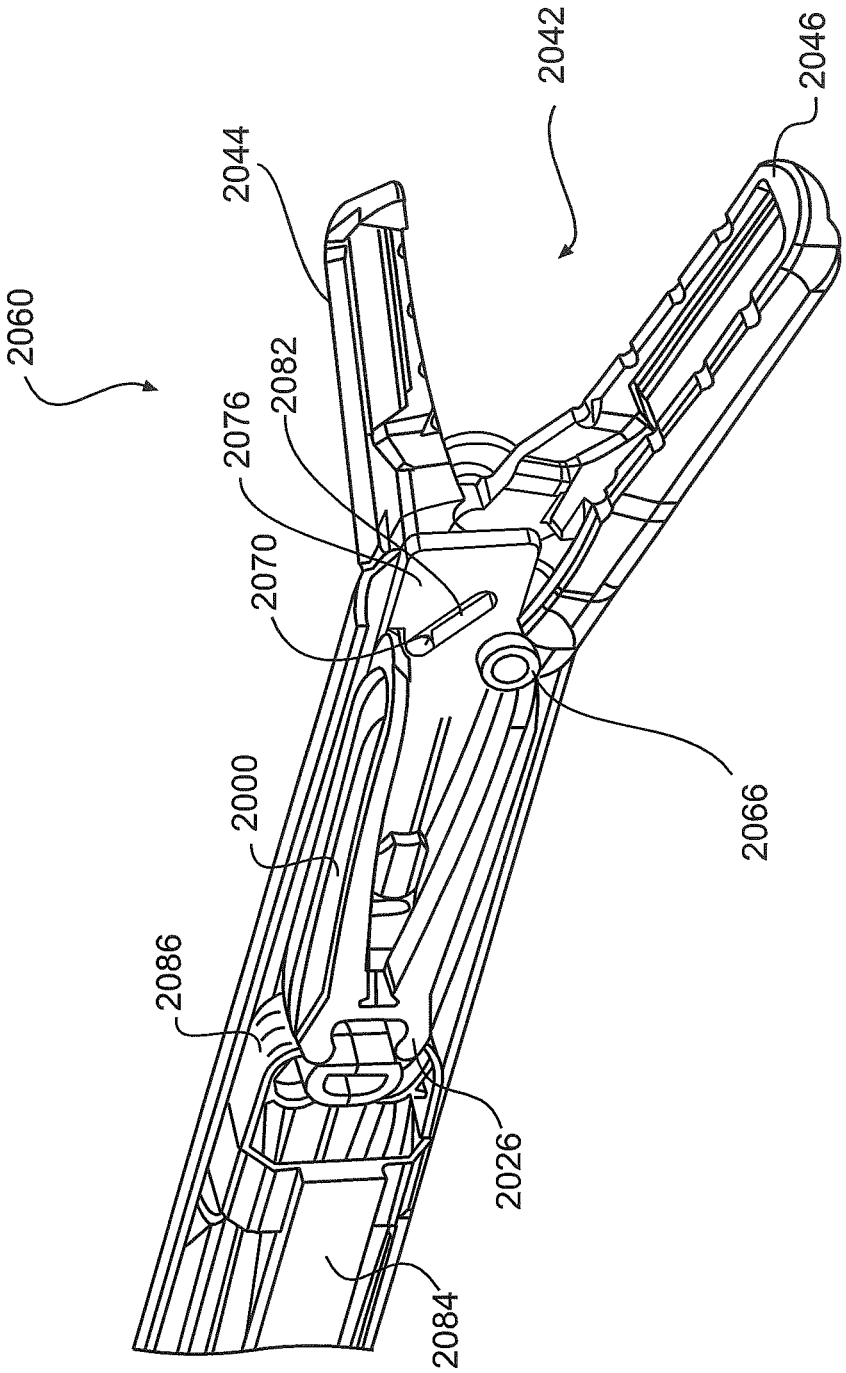

FIG. 124

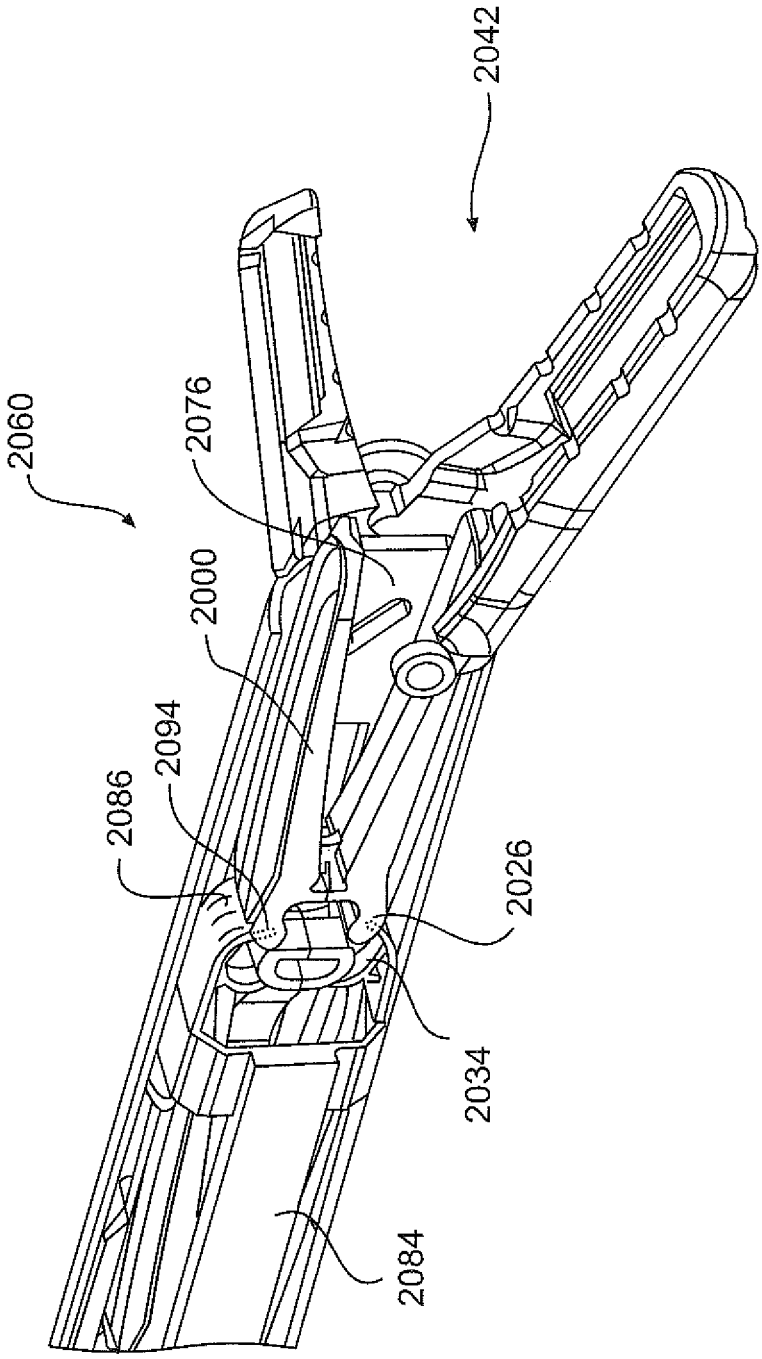

FIG. 125

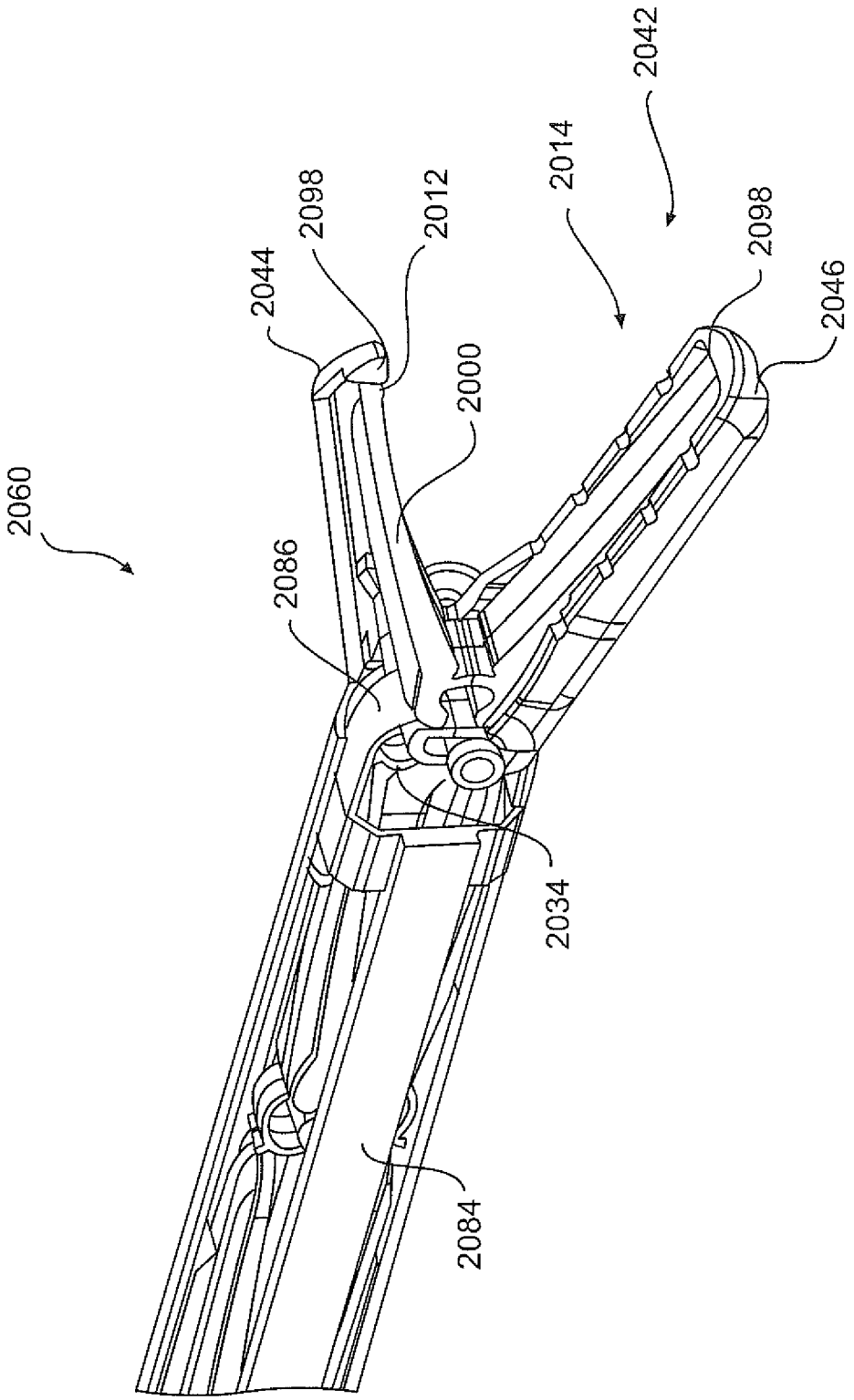

FIG. 126

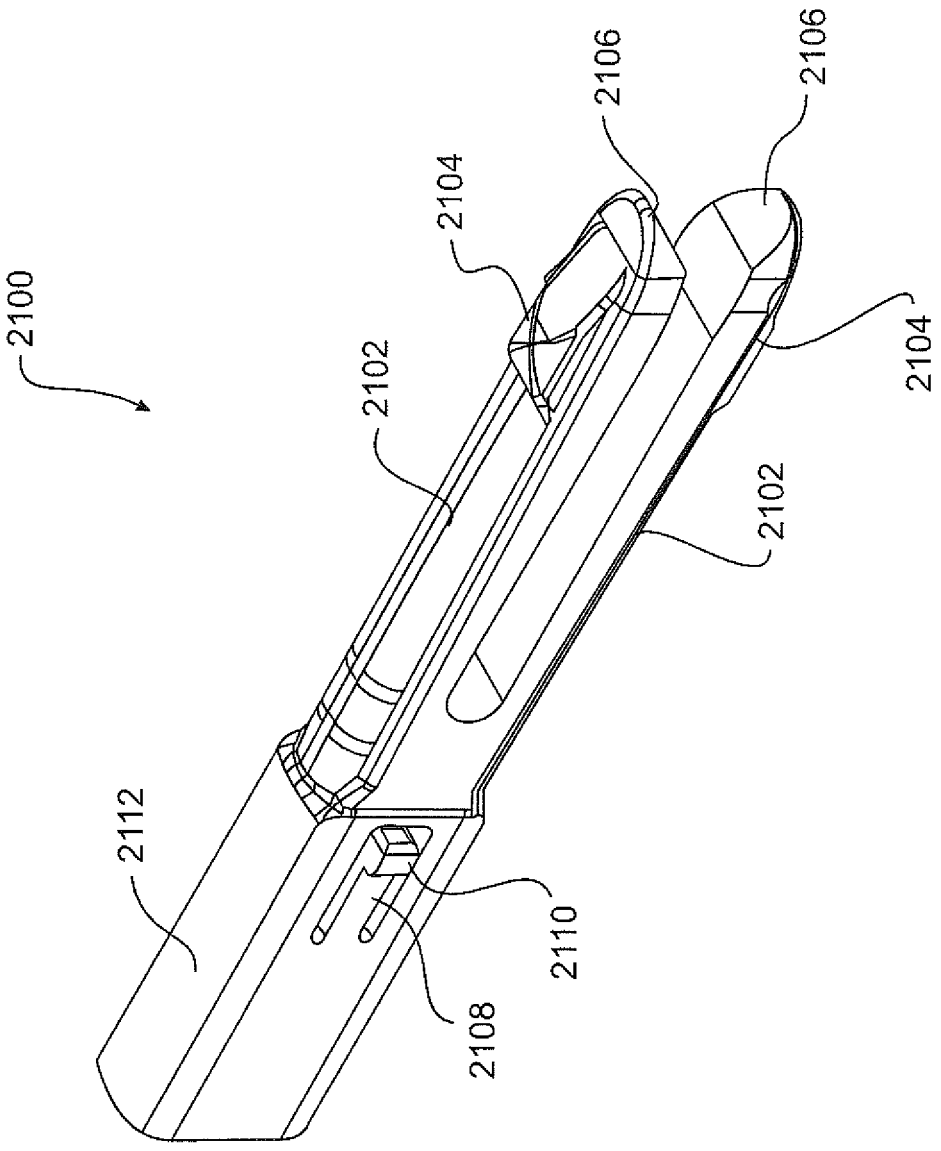

FIG. 127

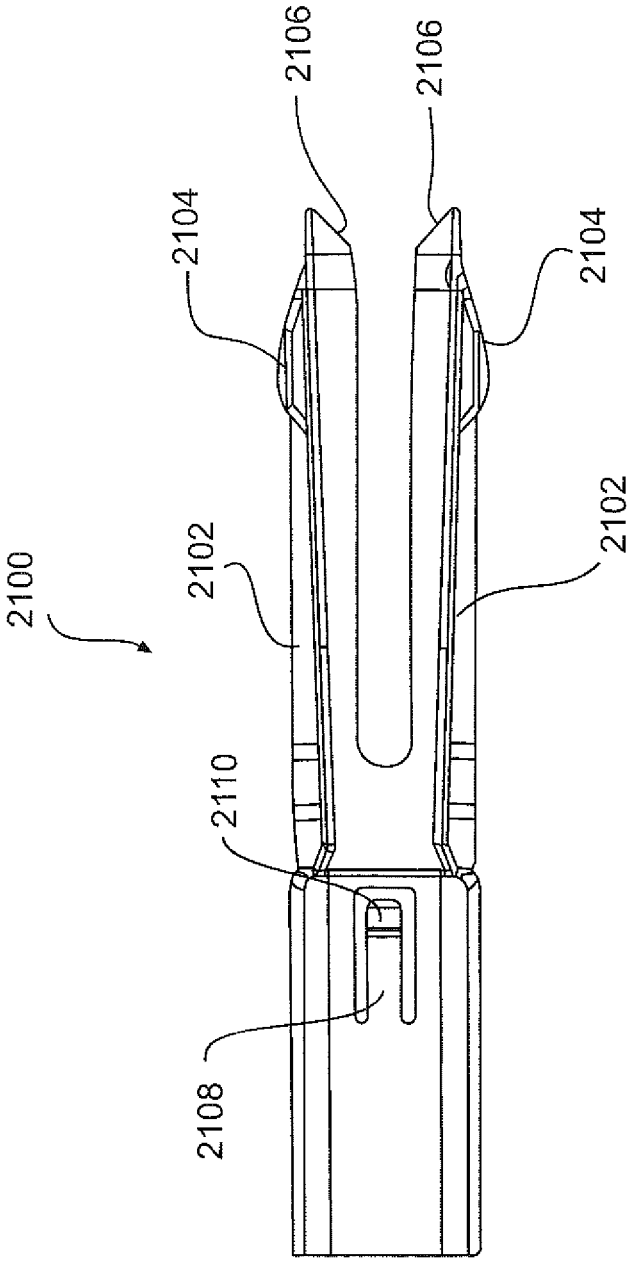

FIG. 128

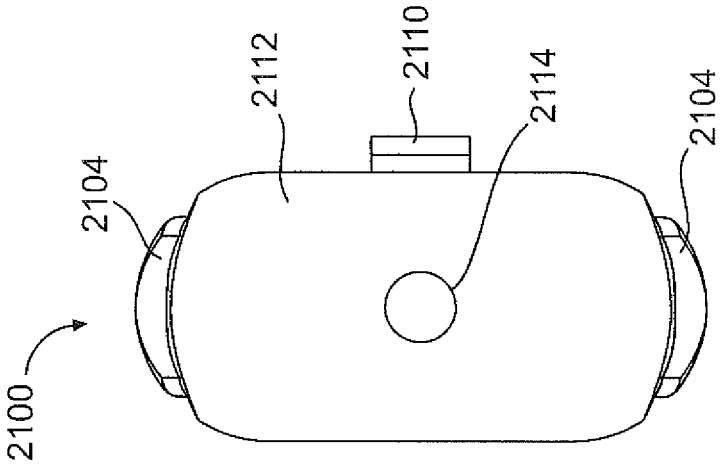

FIG. 129b

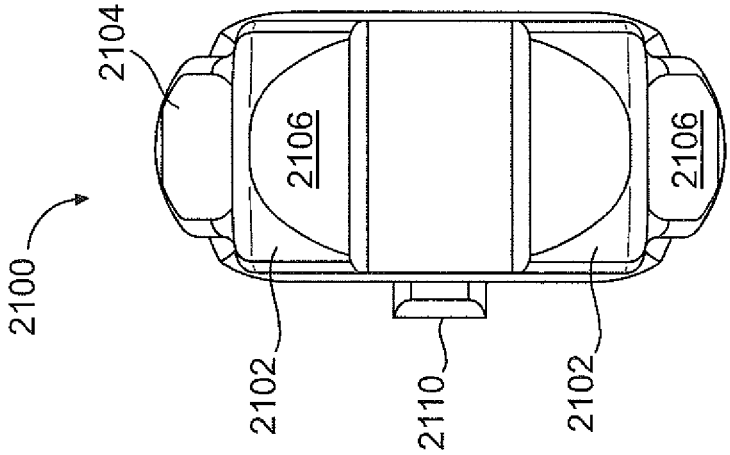

FIG. 129a

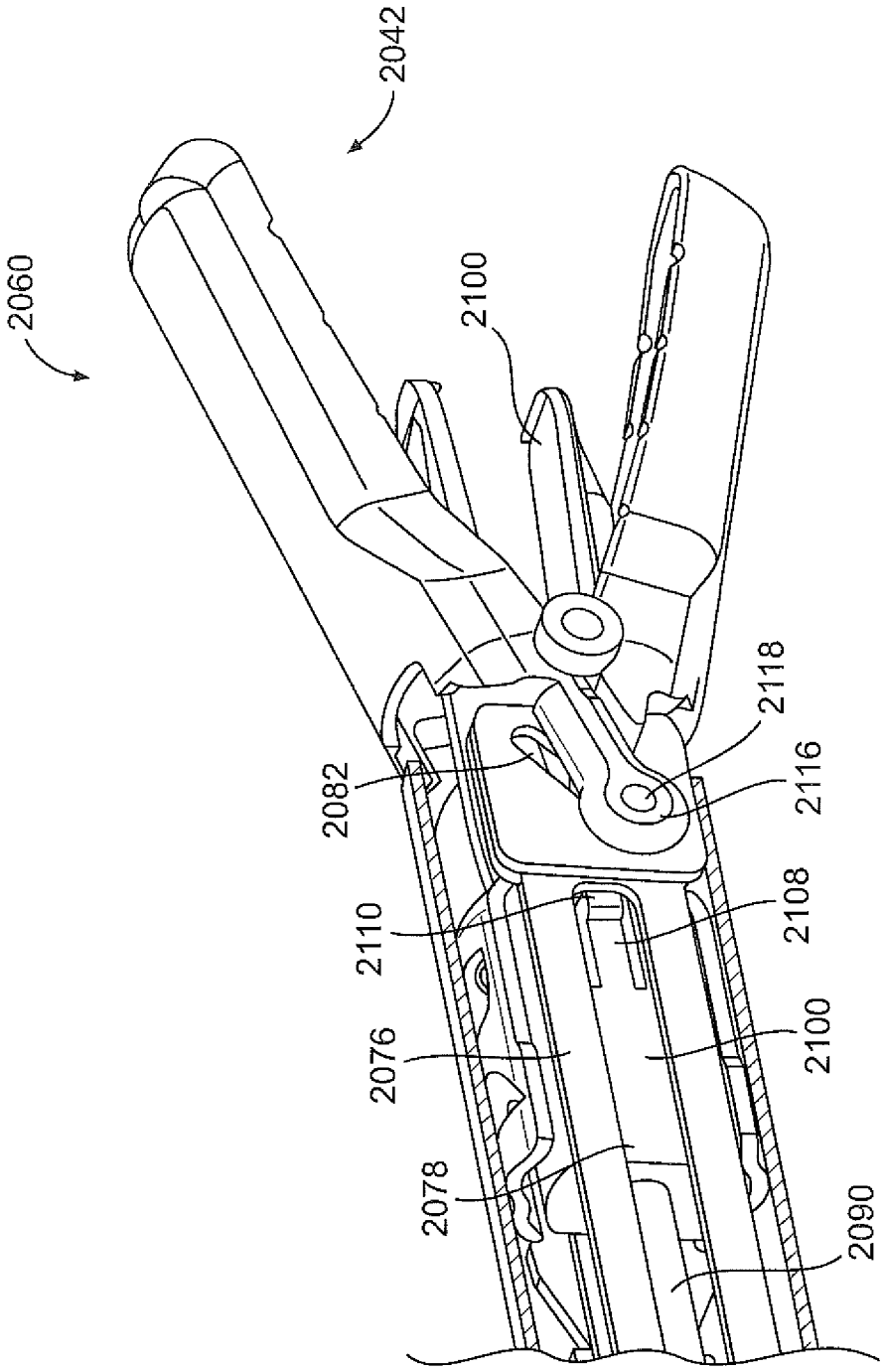

FIG. 130

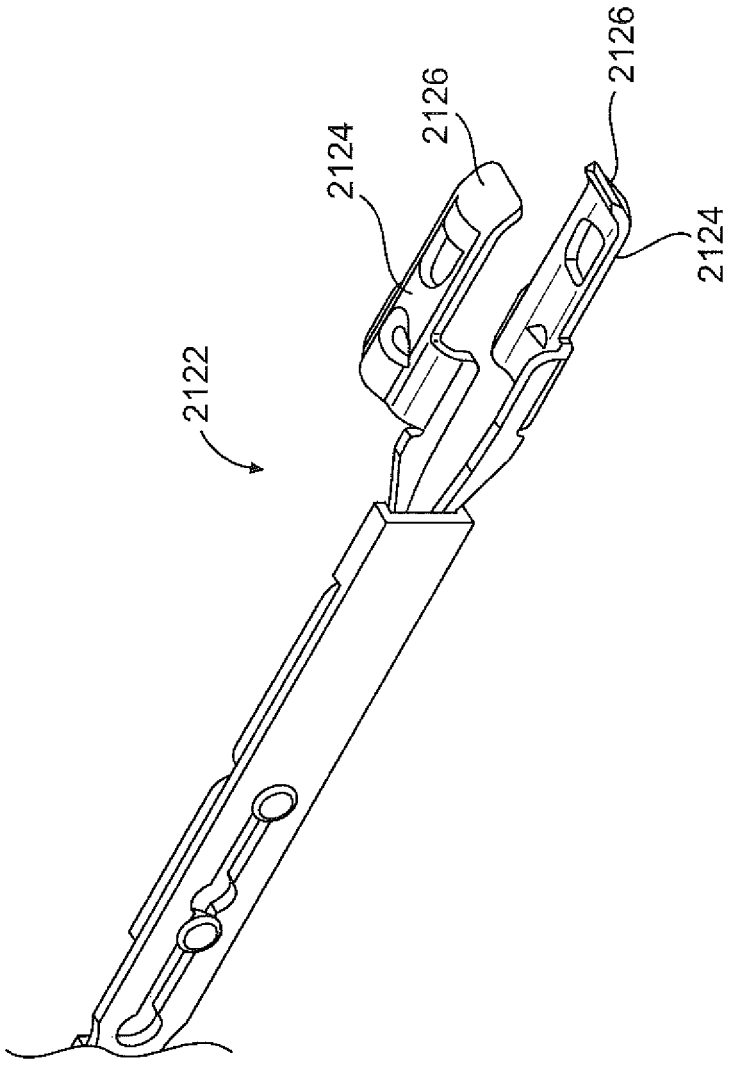

FIG. 131

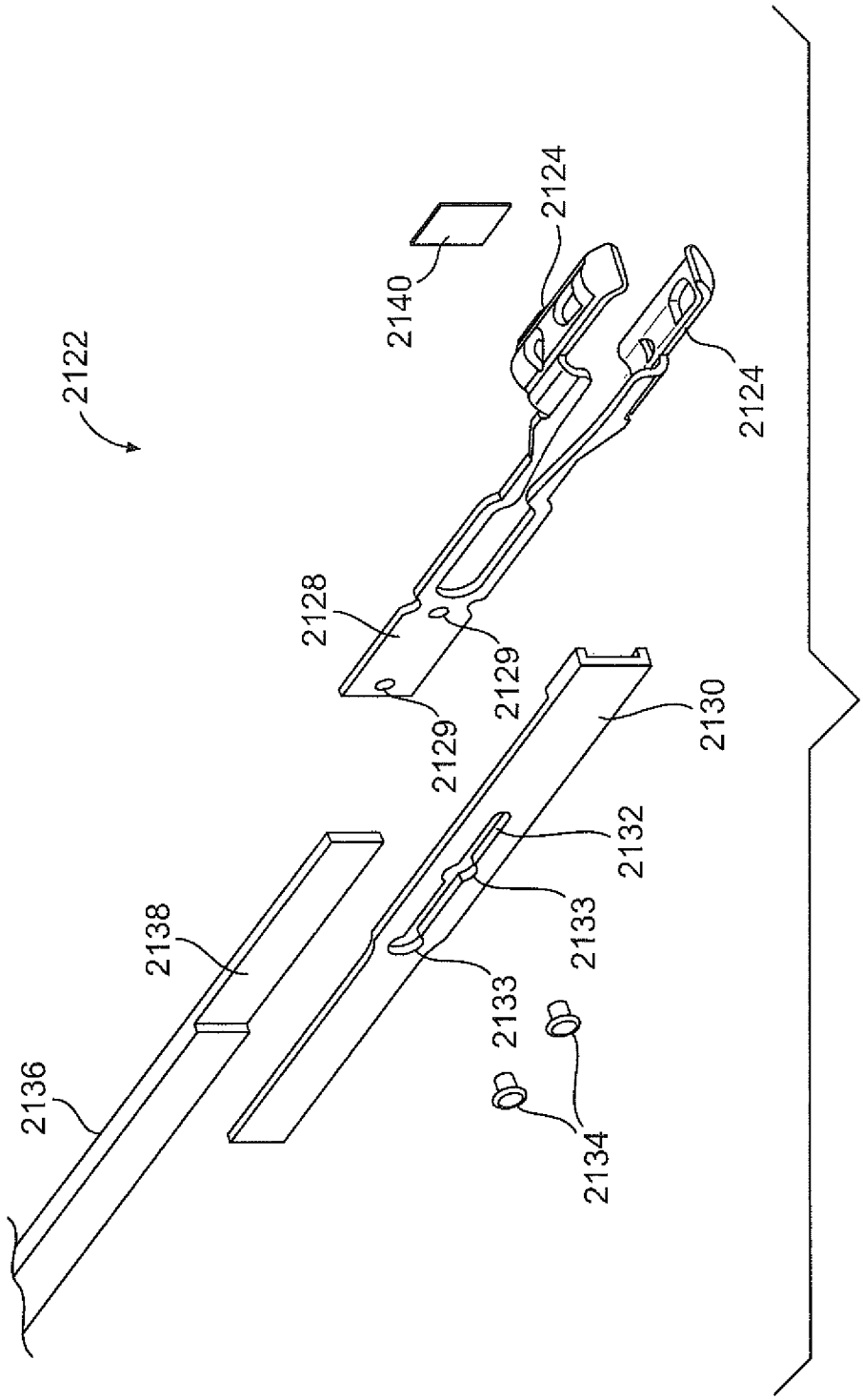
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FIG. 132

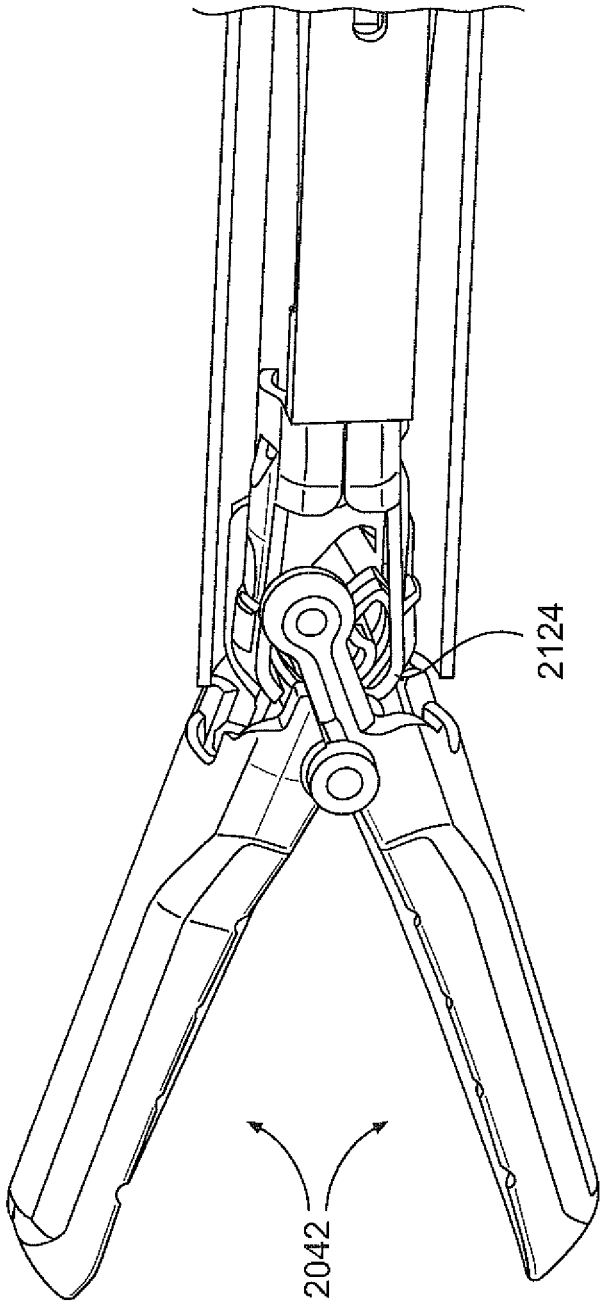

FIG. 133

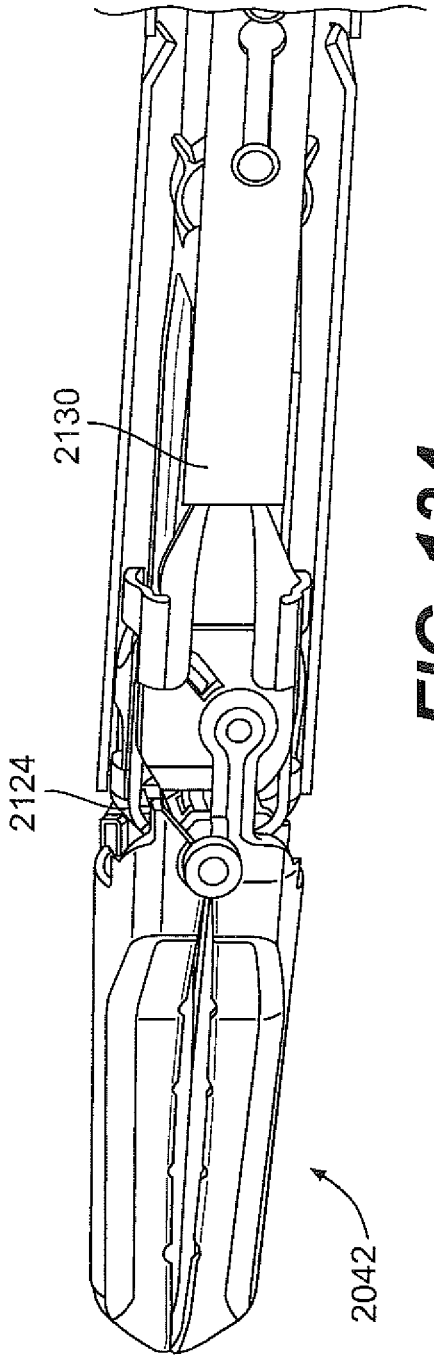

FIG. 134

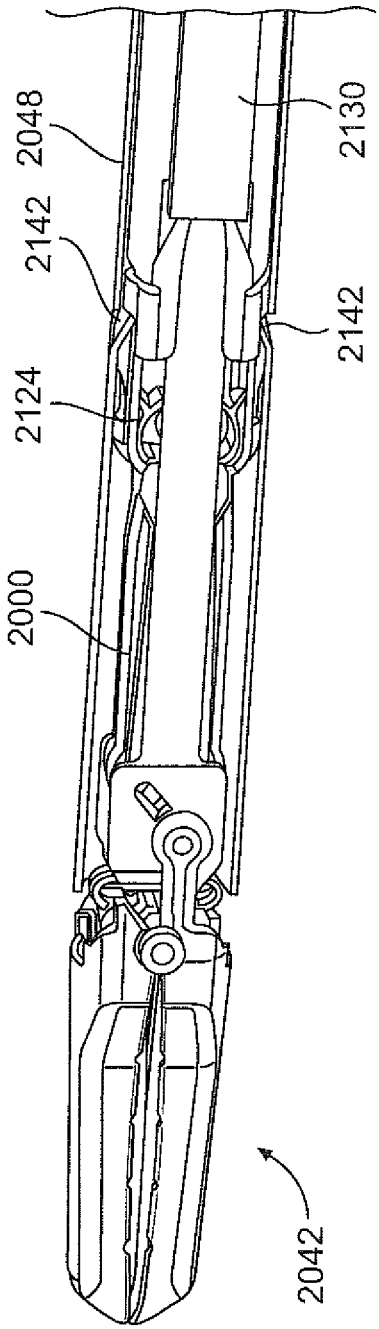

FIG. 135

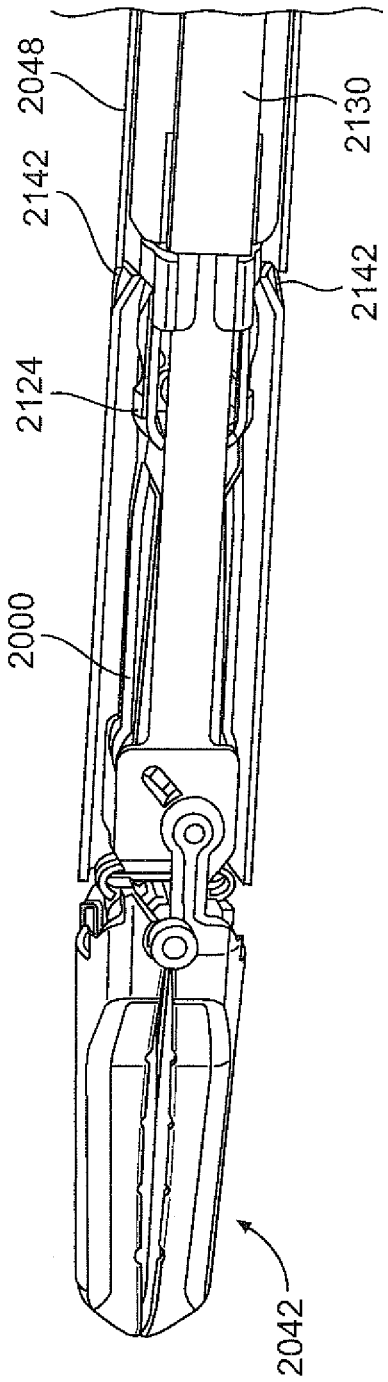

FIG. 136

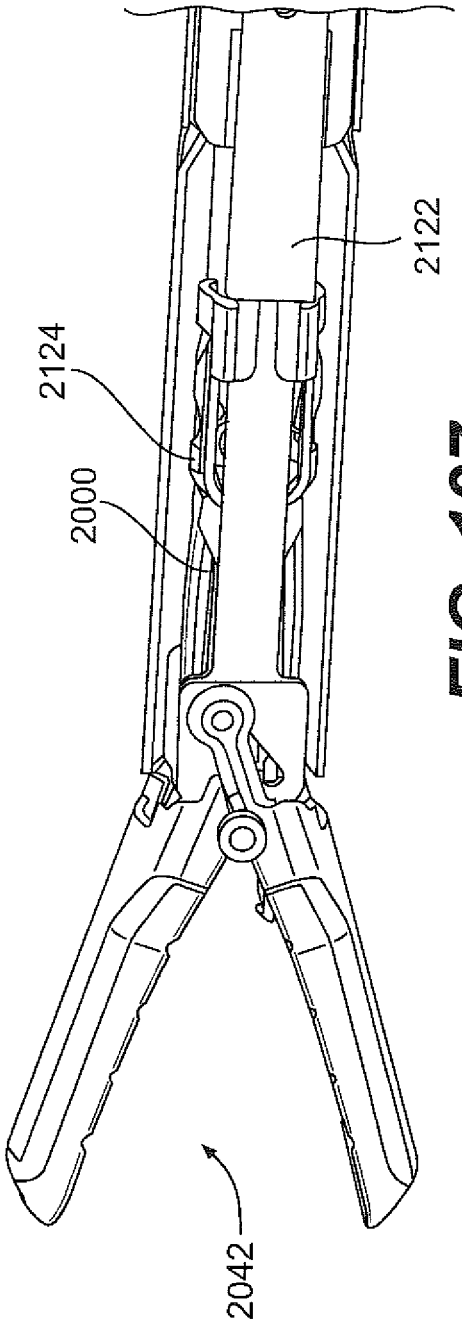

FIG. 137

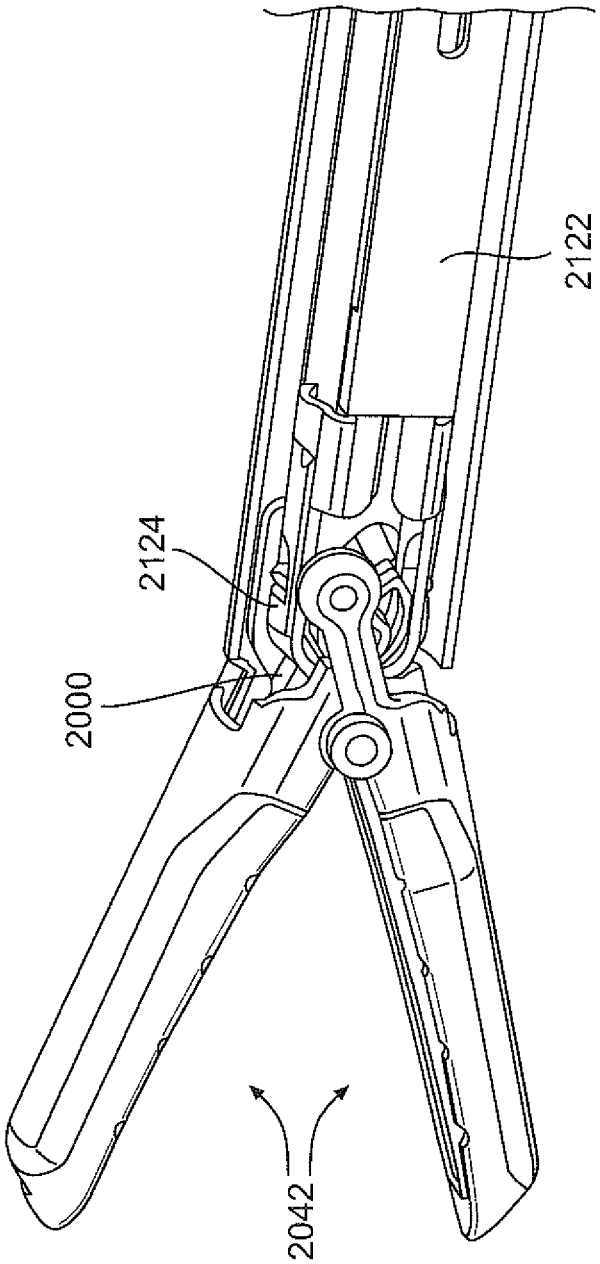

FIG. 138

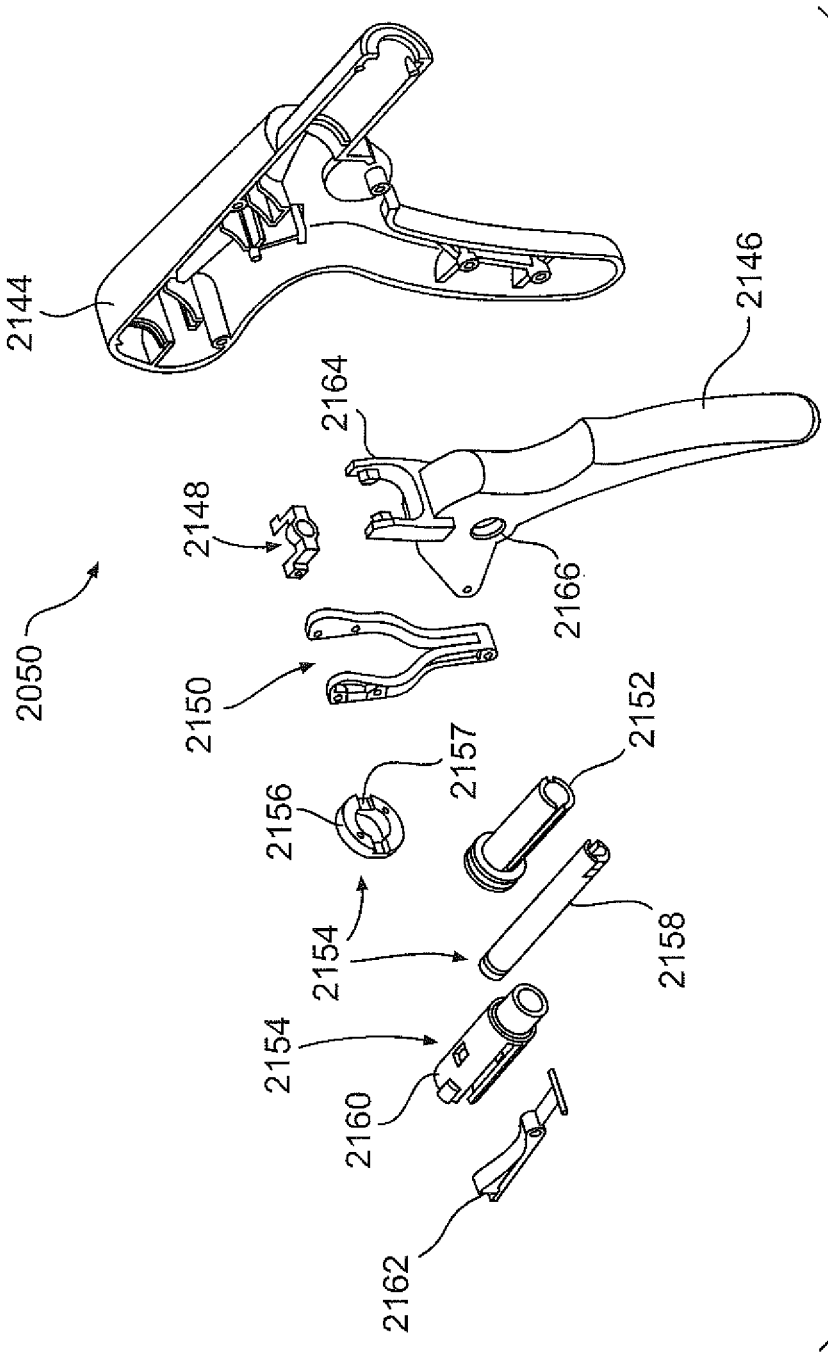
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FIG. 139

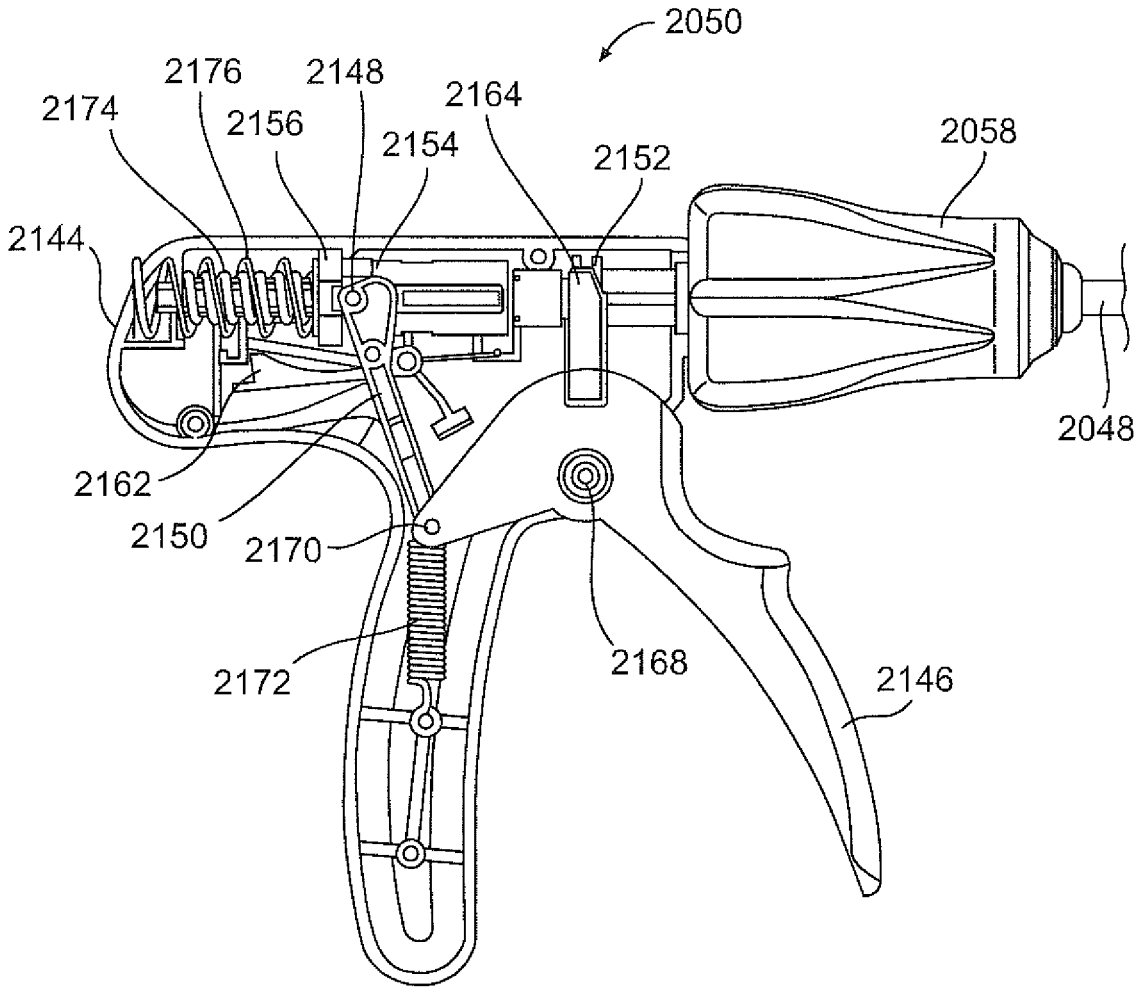
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FIG. 140

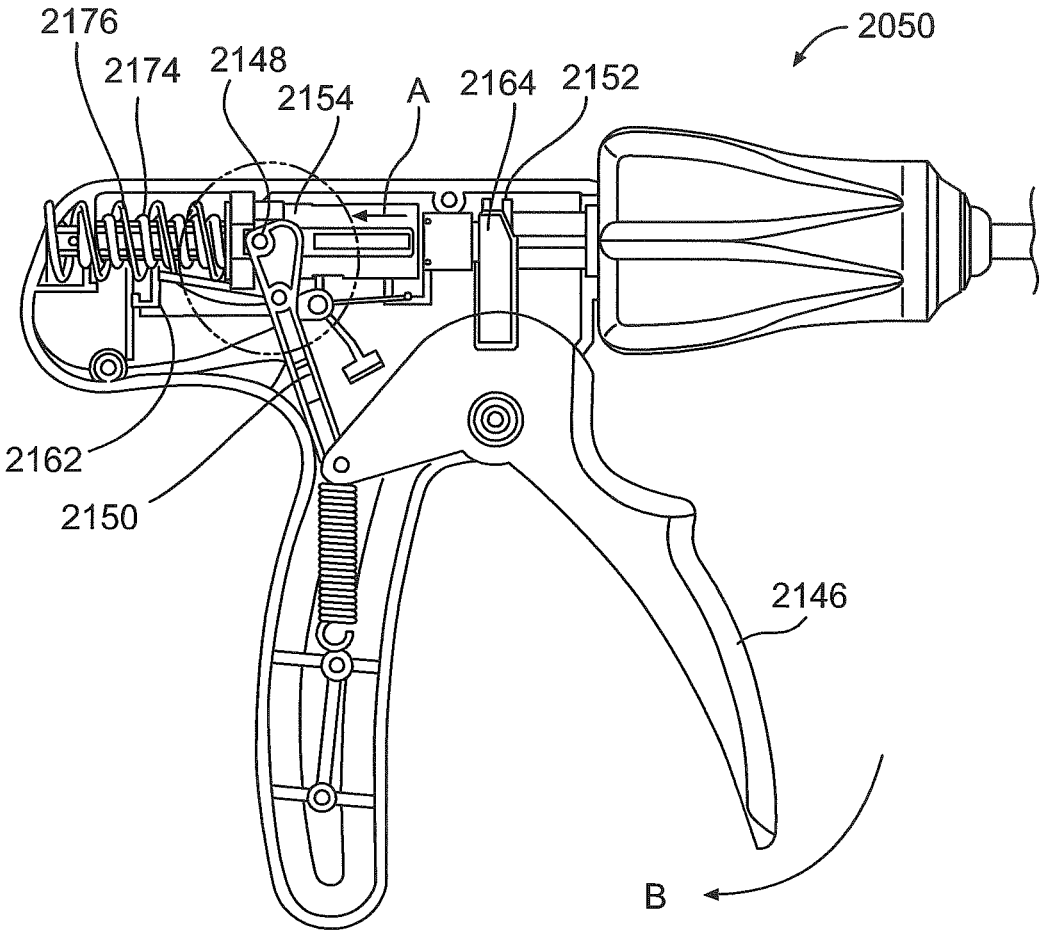

FIG. 141

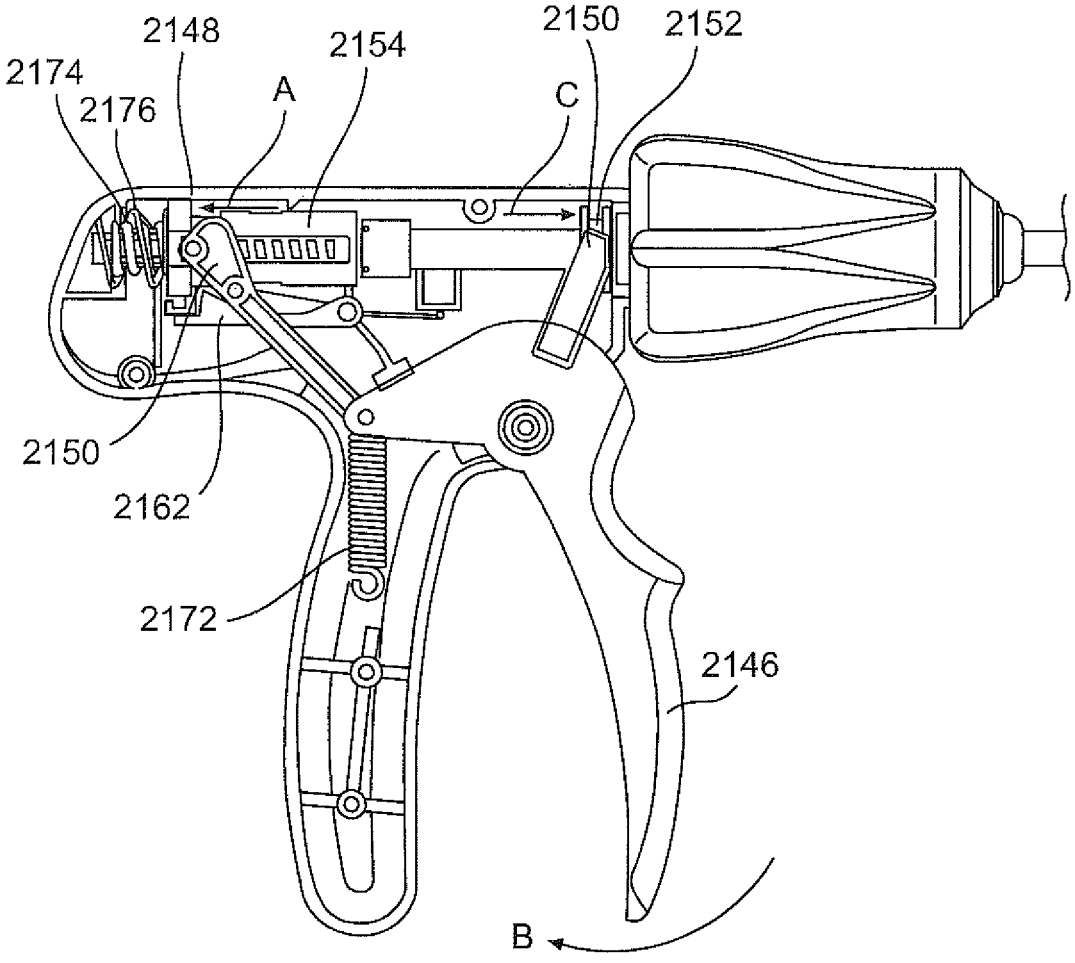

FIG. 142

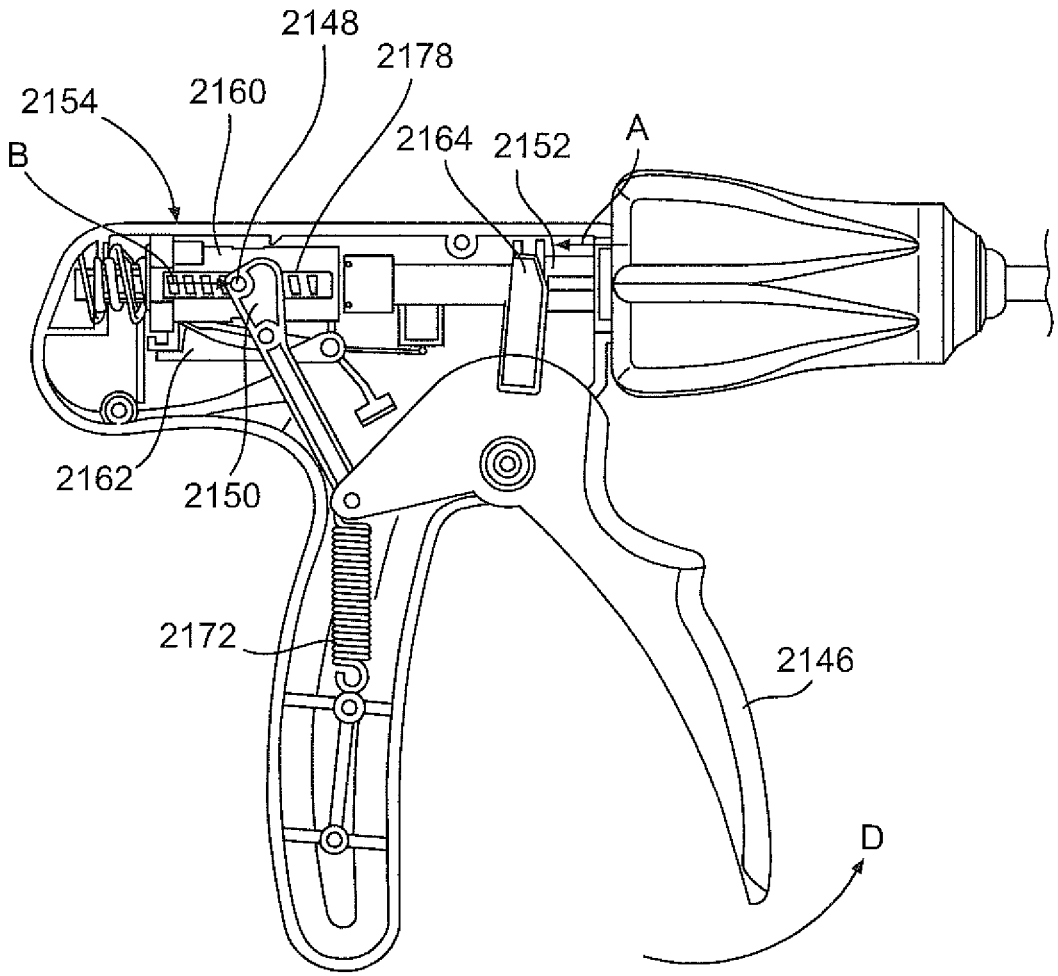

FIG. 143

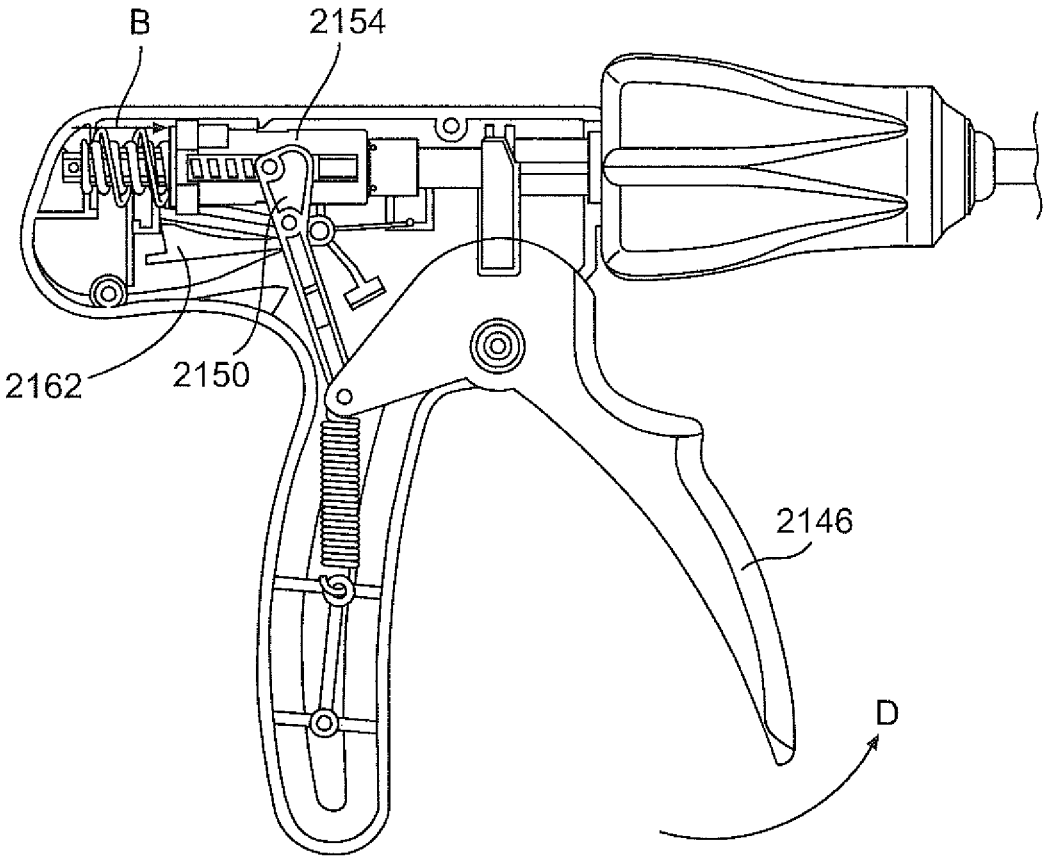

FIG. 144

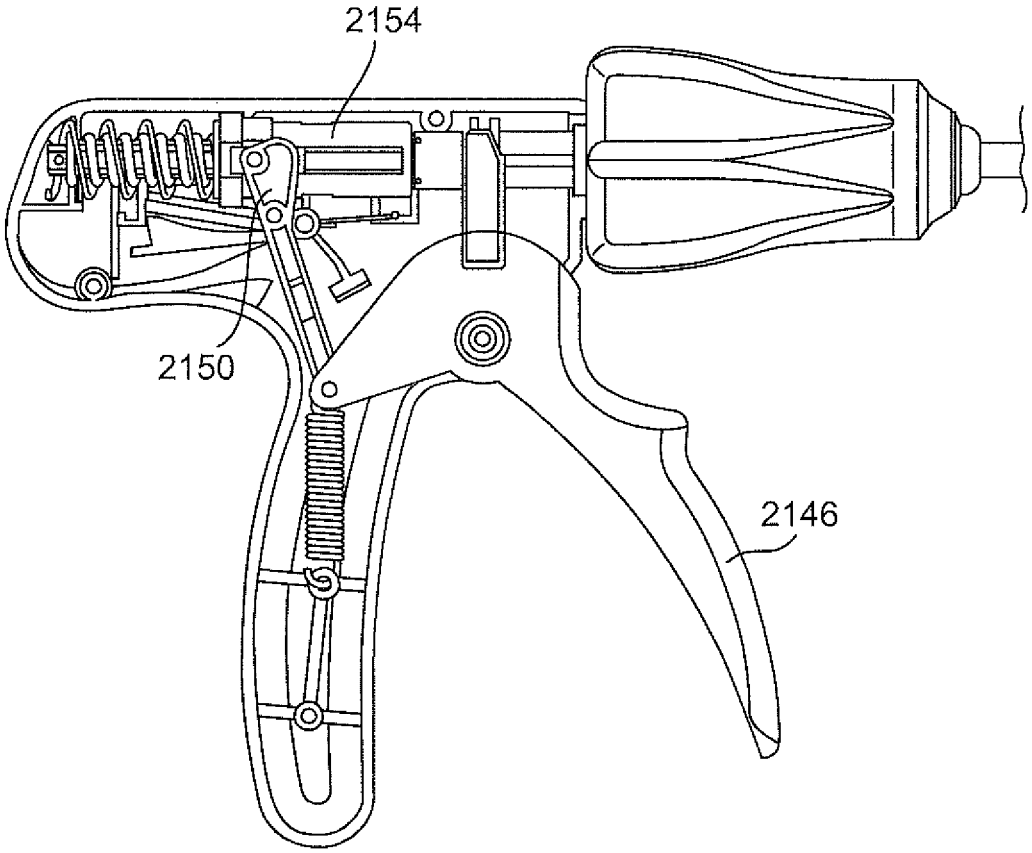

FIG. 145

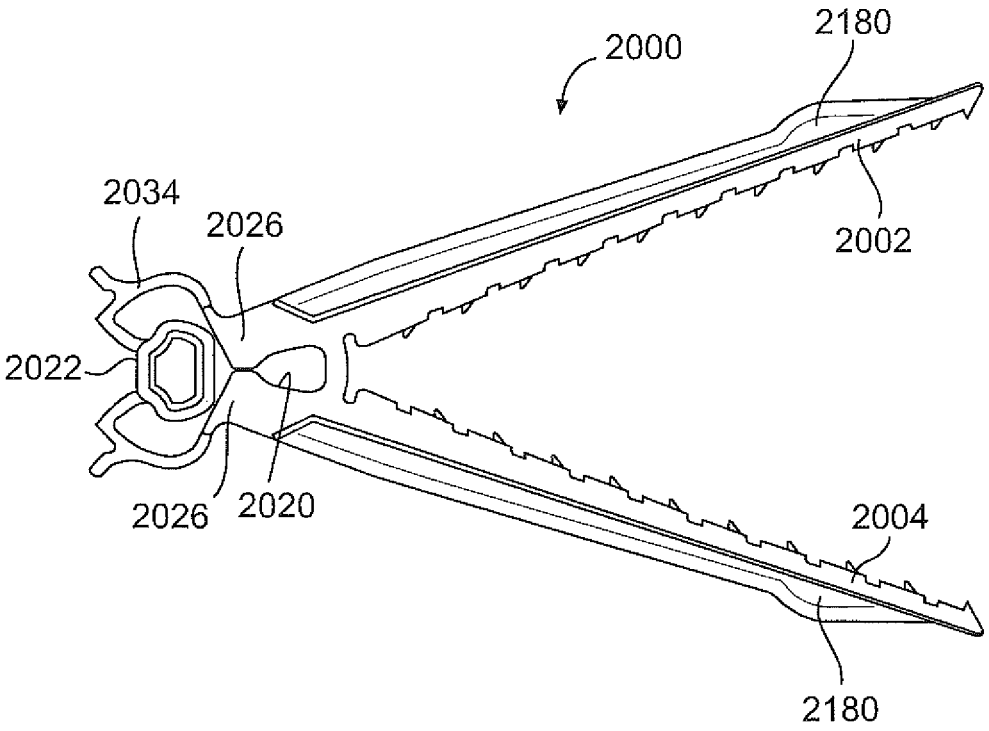

FIG. 146

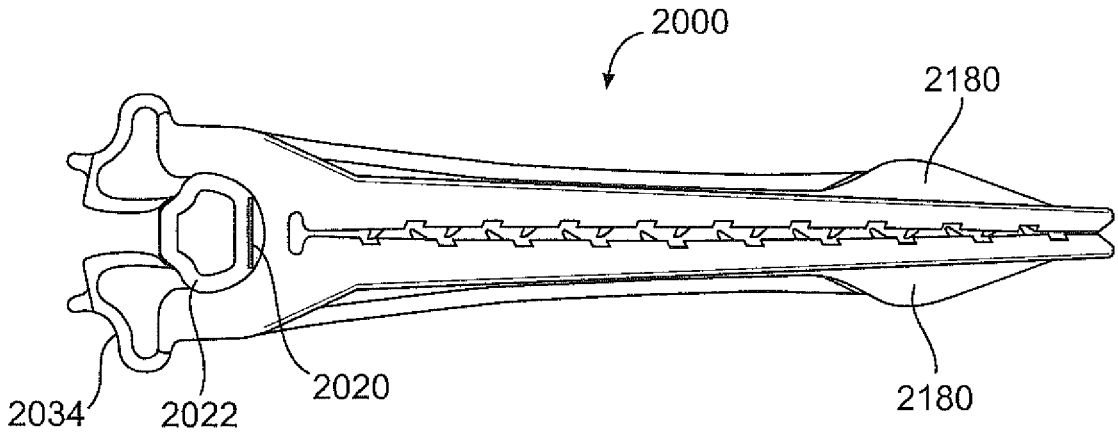

FIG. 147

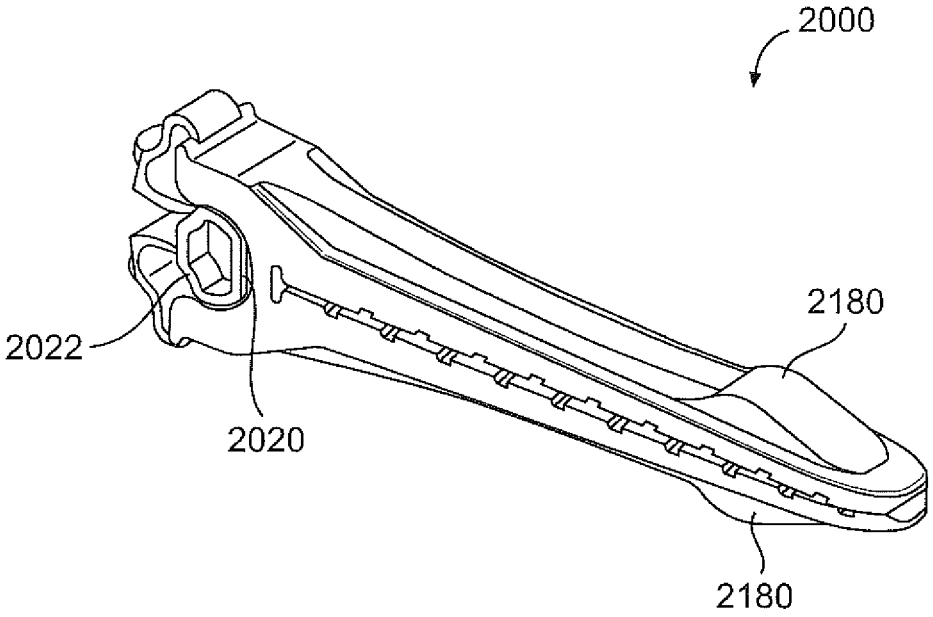

FIG. 148

AUTOMATIC SURGICAL LIGATION CLIP APPLIER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to provisional U.S. patent application entitled, Automatic Surgical Ligation Clip Applier, filed Sep. 15, 2011, having a Ser. No. 61/535,166, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to medical devices and, in particular, a device for applying surgical clips for ligation of vessels or tissue.

BACKGROUND

Many surgical procedures require vessels or other fluid ducts or tissue conduits and structures to be ligated during the surgical process, such as, for example, veins or arteries in the human body. For example, many surgical procedures require cutting blood vessels, and these blood vessels may require ligation to reduce bleeding. In some instances, a surgeon may wish to ligate the vessel temporarily to reduce blood flow to the surgical site during the surgical procedure. In other instances a surgeon may wish to permanently ligate a vessel. Ligation of vessels or other tissues can be performed by closing the vessel with a ligating clip, or by suturing the vessel with surgical thread. The use of surgical thread for ligation requires complex manipulations of the needle and suture material to form the knots required to secure the vessel. Such complex suture material to form the knots required to secure the vessel. Such complex manipulations are time-consuming and difficult to perform, particularly in endoscopic surgical procedures, which are characterized by limited space and visibility. By contrast, ligating clips are relatively easy and quick to apply. Accordingly, the use of ligating clips in endoscopic as well as open surgical procedures has grown dramatically.

Various types of hemostatic and aneurysm clips are used in surgery for ligating blood vessels or other tissues to stop the flow of blood. Such clips have also been used for interrupting or occluding ducts and vessels in particular surgeries such as sterilization procedures. Typically, a clip is applied to the vessel or other tissue by using a dedicated mechanical instrument commonly referred to as a surgical clip applier, ligating clip applier, or hemostatic clip applier. Generally, the clip is left in place after application to the tissue until hemostasis or occlusion occurs.

Ligating clips can be classified according to their geometric configuration (e.g., symmetric clips or asymmetric clips), and according to the material from which they are manufactured (e.g., metal clips or polymeric clips). Symmetric clips are generally "U" or "V" shaped and thus are substantially symmetrical about a central, longitudinal axis extending between the legs of the clip. Symmetric clips are usually constructed from metals such as stainless steel, titanium, tantalum, or alloys thereof. But, with the advent of high technology diagnostic techniques using computer tomography (CATSCAN) and magnetic resonance imaging (MRI), metallic clips have been found to interfere with the imaging techniques. To overcome such interference limitations, biocompatible polymers have been increasingly used for surgical clips.

Some well known polymeric clips are disclosed in U.S. Pat. No. 4,834,096 and U.S. Pat. No. 5,062,846. These plastic clips generally comprise a pair of curved legs joined at their proximal ends with an integral hinge or heel, and a closure or locking mechanism at their distal ends. Another example of a bio-compatible clip is shown in U.S. Pat. No. 4,671,281, which includes a mechanism to be actuated on a proximal end of the clip for causing the distally extending legs of the clip to converge. However this clip is: (i) rudimentary in construction, (ii) does not provide adequate clip closing or clamping strength, (iii) lacks any complex geometry which would adequately retain the clip in a closed position, and further (iv) is too unstable when closed to be safely applied over vessels. Examples of metal hemostatic clips are shown in U.S. Pat. No. 3,326,216 and U.S. Pat. No. 5,908,430.

In all of the known ligating clips however, there remains a need to improve the effectiveness of clamping about a vessel, while minimizing the damage to the vessel and surrounding tissue. For endoscopic surgical procedures, it is important to use tools and instruments that have the smallest, narrowest profile possible, such as the shafts of a tubular endoscope. Prior art polymeric and metal clips do not lend themselves to deployment through small diameter instrumentation, such as, for example, a ~5 mm endoscope. Known prior art clips can be very wide profile, especially when in the open position prior to closure and ligation, and thus require larger, wider endoscopic instruments and appliers for use in surgery. It is desirable therefore to provide for a surgical ligation clip that has the narrowest profile possible. It may also be desirable to allow for a clip to be opened again after initial closure, which is especially a problem with known surgical clips, such as metal hemostatic clips. Furthermore, prior art polymeric clips involve locking the distal ends of their legs together in order to clamp down on the vessel or structure being ligated. Such closure of a clip having locking parts at its distal end generally causes or requires dissection, removal, or clearance of additional surrounding tissue, in order to allow the clip's locking features to come together, and/or due to actuation of an applier tool surrounding or applied against the distal clip ends, requiring additional time during a surgical procedure and damage to tissue. In other cases, the user may choose not to prepare a path for the locking features and rely on the locking features penetrating through the tissue. In these cases, the locking feature may have difficulty penetrating the tissue or may have difficulty locking after it has penetrated the tissue. This technique may also result in unintended penetration of tissue or vessels.

Therefore it is desirable to provide a clip and a method and/or device for applying the clip which minimizes such dissection of tissue during application. It is further desirable to provide a clip which provides a proper, well-calibrated, reliable clamping force, such that the clip when closed is stable around the vessel ligated.

Accordingly, there is a need to provide an improved surgical ligating clip and a method and/or device for applying the clip, where the clip serves to reliably secure the tissue or vessel engaged by the clip, while robustly remaining attached to the vessel with a minimum level of damage to tissue.

SUMMARY OF THE INVENTION

The invention provides, in one or more embodiments, a surgical ligation clip and a device and/or a method of applying the clip to a vessel or tissue. The device may contain a plurality of clips and may apply a first clip to a vessel or tissue and advance a second clip contained in the applier to an applying position.

In another aspect of the invention, a method of applying a surgical ligation clip includes positioning the clip in an open position proximate an inner anatomical body vessel, the clip having first and second legs each extending along a longitudinal axis of the clip and having proximal and distal end portions with respect to said longitudinal axis, a clip hinge means joining the first and second legs at a point on their respective proximal end portions, the first and second legs each having inner clamping surface means between the clip hinge and the distal end portions of said first and second legs, the clamping surface means being apposed when the clip is in a fully closed position, and a locking means for biasing the legs closed extending proximal to the clip hinge means. An external force is applied substantially along the longitudinal axis to a proximal end portion of one of the legs which forms a portion of the locking means, to move a body formed as a first part of said locking means from a first position to a second position to provide an abutment force between a curved planar segment abutment portion of said body and a curved surface formed on a second part of said locking means disposed on the first leg to bias the clip in a closed position. The method may further include moving the clip through an instrument prior to positioning the clip proximate the vessel, and may also further include that a portion of the instrument opens the clip from a closed position to an open position.

The applier is an instrument used to deploy multiple proximal locking polymeric ligation clips, the number of clips within the applier is proportional to the length the distal end of the applier and the length of the clip. The automatic applier applies a single clip at a time with the ability to repeat the application multiple times without moving from the surgical site. The applier is an endoscopic instrument suitable for use in laparoscopic surgery applications.

The jaws of the applier will be able to actuate without disturbing the loaded clip. This allows the jaws to be used in the dissection and grasping of tissue around the vessel being ligated if necessary.

In one embodiment of the invention; the jaws of the applier will clamp over the vessel to flatten the section to be ligated. The clip is opened internally in the applier by a set of wedges. The clip is then positioned over the vessel and subsequently closed with actuation of the wedges and final pusher mechanisms. The clip is then closed with the wedges and a second clip, proximal to the first clip, engages the locking feature on the first clip and locks the clip to maintain the clamping pressure of the clip. The jaws then open allowing the ligated vessel and clip to clear the applier jaws. The internal components of the applier return to their start positions and the second clip becomes the first clip. This repeats until the applier is out of clips. The last clip is locked with a false clip that stays internal to the applier. When all clips have been delivered the false clip assists with the handle lockout which prevents the user from being able to use the ligation portion of the applier. The jaws continue to actuate.

In one embodiment of the invention; the jaws of the applier will clamp over the vessel to flatten the section to be ligated. The clip is pushed through a channel and into a set of doors with features on the underside that opens the clip. The clip is then positioned partially over the vessel with forward movement of the channel and clip advancers. The movement stops and the clip is advanced fully over the vessel with the clip advancers, at this time the clip is pushed out of the doors. The doors swing together and become the surface that is used to latch the clip. With the doors closed the channel continues forward and latches the clip. The jaws then open allowing the ligated vessel and clip to clear the applier jaws. The internal components of the applier return to their start positions and the second clip becomes the first clip. This repeats until the applier is out of clips.

Each of the distal end actuations are accomplished through the use of a proximal handle. The handle is made of a housing and rotation knob, which allow for a 360° continuous rotation of the distal end, separate triggers for jaw actuation and clip functions, and a multi-stage transmission that allows the distal end to be actuated in the proper sequence for effective clip delivery.

In one embodiment, the applier has a transmission that has at least two inputs. the inputs are manipulated by a jaw actuation trigger and a clip function or ligate trigger. The transmission is connected to clip advancers and the jaws of the applier and transform the trigger positions to articulations of the jaws and/or the clip advancers.

In one embodiment, a method of moving clips through an applier, attaching a clip to a vessel or tissue is provided.

In an embodiment, an applier for ligation clip is provided. The applier includes: an outer tube having mounting bosses; a pair of jaws pivotally connected to the mounting bosses, the jaws having actuating projections; a feed tube located in the outer tube and configured to move axially within the outer tube, the feed tube having actuating slots in which the actuating projections are located; a clip lock arm located in the outer tube and configured to move axially within the outer tube; and a clip advance arm located in the outer tube and configured to move axially within the outer tube, the clip advance arm having flexible pinchers at one end of the clip advance arm.

In an embodiment, a method of applying a ligation clip includes: sliding a feed tube forward thereby camming a projection on a jaw to move the jaw to an open position; sliding a clip arm forward thereby pushing a clip into the jaws; sliding the feed tube rearward thereby camming the projection on the jaw to move the jaw to a closed position; and advancing a clip arm to a forward position to push a buttress on the clip into a buttress locking void thereby locking the clip and a closed position.

In an embodiment, an applier for ligation clip may include: an outer tube having mounting bosses; means for clamping pivotally connected to the mounting bosses, the means for clamping having actuating projections; means for opening and closing the means for clamping located in the outer tube and configured to move axially within the outer tube, the means for opening and closing the means for clamping having actuating slots in which the actuating projections are located; means for locking a clip in closed position located in the outer tube and configured to move axially within the outer tube; and means for advancing a clip located in the outer tube and configured to move axially within the outer tube.

There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are additional embodiments and features of the invention that will be described below.

In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology

and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a view of a first embodiment of a surgical ligation clip of the present invention;

FIGS. **2***a*, **2***b*, and **2***c* show side, top, and bottom views respectively, of the clip shown in FIG. **1**;

FIGS. **3** and **4** show perspective views of the clip shown in FIG. **1** from a first side;

FIG. **5** shows a perspective view of the clip shown in FIG. **1** from the side opposite to that shown in FIGS. **3** and **4**;

FIG. **6** is another side view of the clip shown in FIG. **1**;

FIG. **6***a* is a close-up detail view of the portion of the clip shown in FIG. **6** in region "**6***a*" therein;

FIG. **6***b* is a sectional view of the clip shown in FIG. **6** taken along section B-B in the direction shown in FIG. **6**;

FIG. **7** is another side view of the clip shown in FIG. **1** from the opposite side to that shown in FIG. **6**;

FIG. **7***a* is a close-up detail view of the portion of the clip shown in FIG. **7** in region "**7***a*" therein;

FIG. **7***b* is a sectional view of the clip shown in FIG. **7** taken along section C-C in the direction shown in FIG. **7**;

FIGS. **8***a*, **8***b*, and **8***c*, are side, top, and bottom views, respectively, of the clip shown in FIG. **1** in an open position;

FIG. **9** is a perspective view from the bottom of the clip shown in FIG. **8***a* in the open position;

FIG. **10** is a perspective side view from the top of the clip shown in FIG. **8***a* in the open position;

FIGS. **11***a*, **11***b*, and **11***c* show side, top, and bottom views respectively, of the clip shown in FIG. **1**, with the proximal locking components in locked position;

FIG. **12** is a perspective view from the top of the clip shown in FIG. **11***a;*

FIG. **13** is a side view of the clip shown in FIG. **11***a;*

FIG. **13***a* is a close-up detail view of the portion of the clip shown in FIG. **13** in region "**13***a*" therein;

FIG. **14** is a side view of the clip shown in FIG. **11***a* from the side opposite to that shown in FIG. **13**;

FIG. **14***a* is a close-up detail view of the portion of the clip shown in FIG. **14** in region "**14***a*" therein;

FIG. **15** is a view of the clip shown in FIG. **1**;

FIG. **15***a* is a close-up detail view of the portion of the clip shown in FIG. **15** in region "**15***a*" therein;

FIG. **16** shows a side view of an applier;

FIG. **17** shows a isometric view of clip latched on vessel;

FIG. **18** shows a clip latched on vessel;

FIG. **19** shows an applier approach to vessel;

FIG. **20** shows an applier clamped on vessel;

FIG. **21** shows a feed rail;

FIG. **22** shows a wedge;

FIG. **23** shows a primary pusher;

FIG. **24** shows a final pusher;

FIG. **25** shows an inner tube;

FIG. **26** shows an outer tube;

FIG. **27** shows a jaw/inner tube camming;

FIG. **28** shows a jaw/inner tube cam points;

FIGS. **29-31** shows jaws;

FIG. **32** shows inner and outer tubes cut away to see interior of distal end;

FIG. **33** shows a top feed rail cut away to see clip and wedge;

FIG. **34** shows a final pusher cut away to show primary pusher;

FIG. **35** shows jaws clamped on vessel;

FIG. **36** shows a start of ligation-wedges, primary & final pushers begin to move;

FIG. **37** shows an open clip advanced into jaws over vessel;

FIG. **38** shows wedges advance to close clip legs down on vessel;

FIG. **39** shows a second clip advanced into first clip rotating buttress and locking first clip;

FIG. **40** shows wedges begin to retract, feeder rails are together keeping the 2 second from retracting;

FIG. **41** wedges continue to retract primary pusher and second clip retract;

FIG. **42** shows second clip stops in notch on feeder rails, wedges and primary pushers continue to retract final pusher begins to retract;

FIG. **43** shows all moving parts return to start position, first clip on vessel is released when jaws are opened;

FIG. **44** shows a last clip in stack is locked with a false clip;

FIG. **45** shows a false clip;

FIG. **46** shows a dual trigger handle;

FIG. **47** show an isometric view of handle;

FIG. **48** shows a handle with shell and knobs exploded showing actuation mechanisms;

FIG. **49** shows internal handle components;

FIG. **50** shows triggers and mechanisms;

FIGS. **51-58** show a pawl mechanism;

FIG. **59** shows transmission parts;

FIG. **60** shows a multi stage transmission;

FIG. **61** shows a outer shell of transmission removed;

FIG. **62** show a jaw actuation links removed;

FIG. **63** shows a back outer shell removed;

FIG. **64** shows a final pusher latches and dowels removed;

FIG. **65** shows a primary pusher latches removed;

FIG. **66** shows center spindles removed distal end connection points shown;

FIG. **67** shows input positions when the jaws are open;

FIG. **68** shows input positions when the jaws are clamped on vessel;

FIG. **69** shows input positions at a start of clip advance;

FIG. **70** shows input positions for a first clip advanced over vessel by final pushers and wedges advance second clip advances by primary pushers;

FIG. **71** shows input positions for wedges to advance to close first clip;

FIG. **72** shows input positions for a clip latch—primary pushers advance second clip to lock first clip;

FIG. **73** shows input positions for wedges to begin to retract;

FIG. **74** shows input positions for primary pushers to retract and wedges continue to retract;

FIG. **75** shows input positions for final pusher to retract other parts continue to retract;

FIG. **76** shows input positions when everything returns to start position-second clip is now the first clip;

FIG. **77** shows a walking beam;

FIG. **78** shows a walking beam;

FIG. **79** shows a walking beam;

FIG. **80** shows a walking beam pusher;

FIG. **81** shows a walking beam pusher;

FIG. **82** shows a punch ring;

FIG. **83** shows a punch door;

FIG. **84** shows a door wedge;

FIG. **85** shows a clip advancer;

FIG. **86** shows a start position;

FIG. **87** shows a clip advancer pushes first clip through doors;

FIG. **88** shows a walking beam and clip advancers move forward to partially advance clip over vessel in jaws. The walking beam pusher stays stationary;

FIG. **89** shows the walking beam stops and the clip advancers push the clip the final distance;

FIG. **90** shows punch doors fully closed against punch ring;

FIG. **91** shows once the doors are closed the walking beam advances again and latches the clip;

FIG. **92** shows the walking beam and clip advancers return to their start position;

FIG. **93** shows a start of clip advance and latch;

FIG. **94** shows a clip pushed through punch doors;

FIG. **95** shows a clip opened by wedges on punch doors;

FIG. **96** shows a clip pushed out of wedge/punch doors;

FIG. **97** shows a clip latched;

FIG. **98** shows a cross section end view with punch doors opened;

FIGS. **99-108** shows a side view of an applier;

FIG. **109** illustrates a side view of the clip according to another embodiment

FIG. **110** illustrates a top view of the clip shown in FIG. **109**;

FIG. **111** illustrates an isometric view of the clip shown in FIG. **109**;

FIG. **112** illustrates an isometric view of a clip engaging a blood vessel;

FIG. **113** illustrates a side view of a clip engaging a blood vessel.

FIG. **114** is an isometric view of an applier records of in accordance with an embodiment of the invention;

FIG. **115** is a partial isometric view of a distal end of an applier;

FIG. **116** is a partial isometric view of the jaws on applier engaging a blood vessel;

FIG. **117** is a isometric, partial, exploded view of a distal end of an applier;

FIG. **118** is a partial cross-sectional view of a midsection of an applier;

FIGS. **119-126** are isometric, cutaway views of the distal end of an applier;

FIG. **127** is an isometric view of a clip stick pusher;

FIG. **128** is a side view of a clip stack pusher;

FIGS. **129**A and **129**B are front and rear views of a clip stick pusher;

FIG. **130** is a partial cutaway distal view of an applier;

FIG. **131** is a partial, perspective view of the distal end of a cam finger assembly;

FIG. **132** is a partial, exploded view of a cam finger assembly;

FIGS. **133-138** are partial cutaway isometric views of the distal end of an applier;

FIG. **139** is an exploded view of a handle portion of an applier;

FIGS. **140-145** are partial cutaway views of the handle portion of the applier

FIG. **146** is a side view of another clip that may be used in accordance with invention;

FIG. **147** is a side view of the clip shown FIG. **146** and a closed position; and;

FIG. **148** is a isometric view of the clip illustrated in FIG. **146**.

DETAILED DESCRIPTION

The invention will now be described with reference to the drawing figures, in which like parts are referred to with like reference numerals throughout. Clips that may be used in accordance with some embodiments of the invention are described in U.S. provisional patent application No. 61/312,156, filed on Mar. 9, 2010, and U.S. non-provisional application Ser. No. 13/042,864, filed on Mar. 8, 2011 by Philip Schmidt, et al. the disclosures of which are both incorporated by reference in their entirety.

FIG. **1** shows a view of a first embodiment of a surgical ligation clip **100** in accordance with present invention. The clip **100** defines a longitudinal axis "L" along its longest dimension and includes a first leg **101** and a second leg **102** each extending along the longitudinal axis L and having proximal **111**, **112** and distal **121**, **122** end portions with respect to said longitudinal axis. As used herein, the term "proximal" shall refer to the portion of the clip referenced herein which is away from the tips of the clip which open, and "distal" shall refer to the portion of the clip at the tips which open, in accordance with the convention that the clip is inserted distal tip first through an instrument towards an anatomical body to be ligated, such that distal generally refers to the direction away from the user or applier of the surgical clip and proximal refers to the direction opposite to distal.

In clip **100**, a clip hinge **130** joins the first and second legs **101**, **102** at a point on their respective proximal end portions **111**, **112**, the first and second legs each having respective inner clamping surfaces **131**, **132** between the clip hinge **130** and the distal ends **123**, **124** of said first and second legs, the clamping surfaces being apposed when the clip is in a fully closed position. As used herein, the term "apposed" when used with regard to the inner clamping surfaces **131**, **132** shall mean close to, or nearly in contact with each other, allowing for some small spacing therebetween or a concave radius of curvature for the clamping surfaces, such to allow for a clipped vessel to reside between such apposed surfaces, as is more fully illustrated herein and with respect to the drawing figures. The clip hinge **130** can include a bar or cylindrically shaped body or tube which defines a lateral pivot axis "P" (shown in FIGS. **2***b* and **2***c*) about which the legs **101** and **102** pivot as the clip moves from open to closed position and vice versa. A first jaw structure **141** on the first leg **101** extends proximal to a transverse axis "T" which is perpendicular to both the longitudinal axis L and lateral pivot axis P, all intersecting at a point "X" centered on the clip hinge **130**, as shown in FIG. **1**. As used throughout herein, the term "lateral" shall directionally mean orthogonal to both the directions of the longitudinal axis L and transverse axis T, and parallel to pivot axis P as shown in the figures. The first jaw structure **141** includes a first curved inner surface **143** extending from the clip hinge **130**, the first curved inner surface **143** having a complex surface which is oriented at changing angles with respect to, but is generally facing towards, the longitudinal axis L, as shown in FIG. **1**. The curved inner surface **143** is therefore substantially concave when viewed from the longitudinal axis (or plane spanning the longitudinal axis and pivot axis). As used herein, the term "substantially concave" shall mean a surface which is concave in overall curvature, but which may include one or more component areas which may have convex segments or protrusions, such as a notch surface or recess for mating thereto. A second jaw structure **142** is on the second leg **102** extending proximal to the transverse axis T and has a second curved inner surface **144** extending from the clip hinge **130**. As used herein, the "curved inner surface" can include either a single smoothly curved surface segment, or a series of connected curved or straight planar segments, which, taken together, form an overall generally curving surface. As described herein, the surgical clip of the present invention provides that the jaws **141** and **142** are each substantially proximal to a transverse plane extending through

transverse axis T and lateral pivot axis P, thus behind the clip hinge **130**, thereby providing a means for actuating the clip legs **101** and **102** and biasing or locking the clip and its mating faces **131**, **132** in a closed position, which biasing or locking means can be actuated and/or applied by acting only on the proximal end portions of the clip **100**, without having to lock the distal ends **123**, **124** to each other or use a clip applier tool which acts on said distal ends **123**, **124**, thereby obviating the need to dissect tissue around the distal end of the clip as in previously known surgical ligation clips.

As shown in FIG. **1**, the means for biasing or locking the clip closed includes a wedge or buttress body **150** which extends from and is connected to the second jaw structure **142** by a first living hinge **160** at a proximal end of said second jaw structure **142**, the buttress body **150** having an outer surface **151** at a proximal first end portion thereof, which is also disposed approximately as the proximal end of the clip **100** overall. The first and second jaw structures **141**, **142** are spaced on opposite sides of the longitudinal axis L and define a locking space **170** there between. The wedge or buttress body **150** is pivotable about the living hinge **160** to move into the locking space **170** such that the outer surface **151** of the proximal first end portion of the buttress body **150** abuts against a proximal portion **145** of the curved inner surface **143** of the first jaw structure **141** to bias the clip in a closed position (as best shown in FIGS. **11***a*, and **12-14**). Although the clip **100** is shown in FIG. **1** in a closed position, this is with the locking means of the first and second jaws **141**, **142** and buttress body **150** being in the "unlocked" position as shown in FIGS. **1**, **2***a*, and **3-7**. Once the buttress body is in the "locked" position as shown in FIGS. **11***a* and **12-14**, the first and second jaws **141**, **142** are urged or spread apart (shown, as an example, by arrows "J**1**" and "J**2**" in FIGS. **13***a* and **14***a*) by action of surfaces of the wedge/buttress body **150** acting on portions of curved inner surfaces **143**, **144**, which act as moments about the clip hinge **130** and lateral pivot axis P to urge the legs **101**, **102** and its inner clamping surfaces **131**, **132** to become more closely apposed to each other, thereby providing additional clamping and closing force over a vessel around which the clip is applied.

A variety of means may be used to actuate the wedge or buttress body **150** from the unlocked position in FIG. **1** to the locked position shown in FIGS. **11***a*, **12-14**. As shown in FIG. **1**, an external force, shown, for example, as arrow "F" in FIG. **1**, may be applied to a proximal end of the pivoting buttress body **150**, in this example the external force F being substantially aligned with the longitudinal axis L. Alternatively, the external force applied may be at a small angle to the longitudinal axis L, such as, for example, a force shown by arrow "F*" shown in FIG. **1**. In either case, the applied external force will create a moment about living hinge **160** to pivot the buttress body **150** into the locking space **170**. The external force may be applied by an actuating rod or other structural means in an applier instrument, or may be another clip as fed through a multi-clip applier. As one example, the clip **100** may be inserted through an instrument having a bore or channel for receiving the clip **100**, through which the clip **100** may travel distally for positioning near a vessel during a surgical procedure. The clip may be inserted in a legs closed position, but with the proximal locking means including buttress body **150** in open, unlocked position. Because the clip **100** can be inserted in such fashion in closed form, the clip forms a narrow profile and can fit in smaller sized surgical instruments, thereby allowing for smaller incisions and tissue dissection or damage during surgery. A rod or other actuating mechanism translating or moveable on the instrument inserting the clip, or a second instrument or second clip used in conjunction with the instrument used for inserting and positioning the clip in place, may be used to lock the clip by application of an external force on the proximal end portion of the clip as discussed above.

Thus, a method of applying a surgical ligation clip on a vessel in accordance with an embodiment of the invention includes positioning a clip, such as, for example, clip **100**, in an open position proximate a vessel, the clip having first and second legs each extending along a longitudinal axis of the clip and having proximal and distal end portions with respect to said longitudinal axis, a clip hinge means joining the first and second legs at a point on their respective proximal end portions, the first and second legs each having inner clamping surface means between the clip hinge and the distal end portions of said first and second legs, the clamping surface means being apposed when the clip is in a fully closed position. A locking means for biasing the legs closed may extend proximal to a transverse axis perpendicular to the longitudinal axis intersecting at a point centered on the clip hinge. The method includes applying an external force to a proximal end portion of the clip or of one of the legs which forms a portion of the locking means, to move a body formed as a first part of said locking means from a first position to a second position to provide an abutment force between said body and a surface formed on a second part of said locking means to bias the clip in a closed position. In the method, an instrument may be used, wherein, in moving the clip through the instrument prior to positioning the clip proximate a vessel, a portion of the instrument opens the clip from a closed position to an open position, such that the legs of the clip open for placement of the clip around a vessel. The locking means may then be applied to the proximal end portion of the clip to move and bias the legs closed and clamp the clip more fully over the vessel.

In FIG. **1**, the clamping surfaces appear substantially parallel to each other, oriented, in the clip closed position, substantially or very close to parallel to a plane extending through the longitudinal axis L and lateral pivot axis P. However, in an embodiment of the invention, the inner clamping surfaces **131**, **132** may be slightly curved concave when facing said surfaces, such that the surfaces bow away from the longitudinal axis L and straighten slightly when clamping force is applied by action of the locking mechanism of the buttress body **150** acting against jaws **141**, **142**. This allows for enhanced grasping and occlusion of vessels around which the clip **100** is applied, wherein the clamping force is spread more evenly across the clamping surface.

The living hinge **160** connecting the wedge or buttress body **150** to the second jaw **142** can be integral to the second jaw **142** such that the clip body of second leg **102** proximal to transverse axis T extends as a single unitary structure including the second jaw **142** and entire wedge or buttress body **150**. Accordingly, in the wedge or buttress body **150**, a lateral beam or curved body **152** connects the living hinge **160** to the rest of the buttress body **150**, which beam **152** curves from the living hinge **160** (which is separated by a distance from the longitudinal axis L) towards the longitudinal axis L. As shown in FIG. **1** portions of wedge of buttress body **150** can be oriented on both sides of longitudinal axis L. The pivot axis of living hinge **160** extends in a lateral direction parallel the lateral pivot axis P of the main clip hinge **130**.

The present invention provides, in various embodiments, a locking mechanism cooperating between the buttress body **150** and another portion of the clip. In the clip **100** shown in FIG. **1**, the proximal end portion **145** of the curved inner surface **143** of the first jaw structure **141** defines a notch **147** recessed from said curved inner surface **143**, and the buttress

body **150** defines a detent **157** formed on the outer surface thereof, the detent **157** mating with the notch **147** when the buttress body **150** is pivoted into the locking space **170** to bias the clip in the closed position, as best shown in FIGS. **11***a*, **12**, and **14**.

FIGS. **2***a*, **2***b*, and **2***c* show side, top, and bottom views respectively, of the clip shown in FIG. **1**. As shown in FIG. **2***b*, the wedge or buttress body **150** can be divided into two lateral sections or portions **150***a* and **150***b*, each on opposite sides of the longitudinal axis L as shown, and can form approximate lateral halves of the buttress body **150**, with a possible space or small channel in-between. Lateral portion **150***b* of the buttress body **150** can have a width in a plane spanning the transverse and longitudinal axes sufficient to exceed a complementary width formed by the locking space **170** to create an interference fit between the proximal end portion **145** of the curved inner surface **143** of the first jaw structure **141** and the outer surfaces **151***a*, **151***b* on the proximal first end portion outer surface **151** of the buttress body **150**, to bias the clip in a closed position. An example of the transverse width of said lateral portion **150***b* is shown as distance "TW**1**" in FIG. **7***a*, with complementary width "TW**2**" being formed by the locking space **170**, it being understood that TW**1** is slightly greater than TW**2** in order to create the interference fit. In the embodiment as shown in FIGS. **1**, **2***b*, and **7***a*, on lateral portion **150***b* there is no detent **157**, and said lateral portion **150***b* of the buttress body is formed by a partial lateral width of the buttress body **150**. Thus, as shown in FIG. **2***b*, the notch **147** and detent **157** are formed on corresponding partial lateral sections or slices of the buttress body **150** and first jaw structure **141**, respectively, this lateral section **150***a* of buttress body **150** being on the opposite side thereof to the lateral section **150***b*. In this manner, the buttress body **150**, once locked into place as shown in FIG. **12**, is prevented from moving laterally from side to side since the notch **147** and detent **157** interlock only extends laterally partially across the clip, the detent **157** being limited in lateral movement by a shoulder **187** formed by a termination of the notch **147** laterally into the first jaw structure **141**, as shown in FIG. **9**. As shown in FIG. **8***b*, the lateral slice of buttress body **150** only extends for a lateral width LW**1** which includes detent **157**, which the lateral slice LW**2** of buttress body **150** on the other side of the clip does not include the detent **157**. In this manner, the proximal locking mechanism of the clip **100** is more stable in lateral directions, which is also useful for keeping all parts of the clip together in the event the living hinge **160** may break.

As best shown on FIG. **5**, the outer surface **151** on proximal first end portion of buttress body **150** on a proximal end of the clip **100** defines one or more surfaces which form a curved planar segment abutment portion, which in the embodiment as shown includes curved planar segment abutment portions **151***a* and **151***b*. As used herein, the "curved planar segment abutment portion" formed by a surface may include a single curved surface segment or a series of curved or straight planar surface segments connected to one another which form an overall generally curved surface, each of the surface segments extending as a surface at least laterally. In the embodiment shown in FIG. **5**, curved planar segment abutment portion **151***a* included planar and curved surface segments formed by the notch **157** and extends laterally for about one-half of the lateral width of clip **100**, curved planar segment abutment portion **151***b* includes planar and curved surface segments which also extend laterally for about one-half of the lateral width of clip **100**. Each of the curved planar segment abutment portions **151***a* and **151***b* on outer surface **151** forms a substantial abutment surface that pushes against complementary curved inner surfaces of jaw **141** to provide a stronger and more stable locking mechanism for clip **100**. This is provided, at least in part, by the relatively larger and wider surface areas, lateral spans, and segmented surfaces with interlock and abut against each other to provide enhanced holding strength and stability, beyond what has been previously known or practiced in the field of surgical ligation clips.

As best shown in FIG. **6***a*, the second curved inner surface **144** on the second jaw structure **142** forms a first laterally spanning recessed groove **146** separated from the clip hinge **130** and a first laterally spanning ball-shaped or rounded protruding surface **148** proximal to said recessed groove **146**, and a distal second end portion of the buttress body **150** forms a second laterally spanning recessed groove **158** and a second laterally spanning ball-shaped or rounded protruding surface **156** distal to said second recessed groove which are shaped complementary to the first rounded surface **148** and first recessed groove **146**, respectively, so as to mate in abutment when the buttress body **150** is pivoted into the locking space **170** to further stabilize and bias the clip in a closed position. The first recessed groove **146**, first rounded surface **148**, second recessed groove **158**, and second rounded surface **156** may extend laterally all the way across the lateral width of the buttress body **150**, such that the first rounded surface **148** and second rounded surface **156** are not spherically shaped but rather form an extended, laterally-spanning, rounded, semi-cylindrical surface which can mate in corresponding semi-cylindrical shaped grooves formed by first recessed groove **146** and second recessed groove **158**.

As shown in FIG. **6***a*, the buttress body **150** can further define a second living hinge **162** extending laterally between the proximal first end portion **150***c* of buttress body **150** and a distal second end portion **150***d*, wherein the proximal first end portion **150***c* including outer surface **151** further pivots about said second living hinge **162** when the buttress body **150** moves into the locking space **170**, allowing the outer surface **151** of the proximal first end portion **150***c* of the buttress body to flex towards the longitudinal axis L prior to abutment against the curved inner surface **143** of the first jaw structure **141**.

As best shown in FIGS. **5** and **12**, the outer surface of the proximal end of the buttress body **150**, or clip **100** itself, defines a V- or L-shaped laterally spanning notch **150***x* on the proximal end of the clip **100** and further defines a laterally spanning flange **150** *y* extending from said notch **150***x* adjacent to the curved planar segment abutment portions **151***a* and **151***b*. Each of notch **150***x* and flange **150***y* may be divided into two lateral sections or components divided by a small space or channel there between as they are disposed on the lateral sectional halves **150***a* and **150***b* of the buttress body **150**. The notch **150***x* provides a receiving space for the tip of an instrument, pushing or actuating rod, or another clip, so as to enable a more stable actuation of the buttress body **150** into locking space **170** to lock the clip **100**. The flange **150***y* may act to limit the movement of buttress body **150** once fully inserted into locked position inside space **170**, and also further stabilizes the locking mechanism for the clip **100**.

In the embodiment shown in FIGS. **1-15**, the buttress body may occupy a majority of a volume defined by locking space **170** when it is moved into clip locked position so as to bias the legs **101**, **102** in a closed position. The volume defined by the locking space is limited by the lateral width of the clip legs **101**, **102** near the hinge **130** and the jaws **141** and **142**. As shown in FIG. **13***a*, the remaining locking space **170'** between jaws **141** and **142**, once the clip is locked by movement of the buttress body **150** into space **170**, is less than half the volume of the locking space **170** as shown in FIG. **6***a*. The presence of

a bulky body like buttress body **150** which occupies the majority of the volume or space between proximal extending jaws **141** and **142** when the clip **100** is in the locked position further provides a greater strength and stability to the locking of said clip.

In the embodiment shown in FIGS. **1-15**, and as shown in FIG. **6***a*, the buttress body **150** can be characterized in one way as having a core mass which has, in a transverse plane spanning the longitudinal and transverse axes, a cross-section which approximately spans a trapezoidal shape, having rounded curved sides extending from the sides TP**1**, TP**2**, TP**3**, TP**4** of the trapezoid. Side TP**1** defines the longest side and one of the parallel sides of the trapezoid, while side TP**2** defines the shorter parallel side. Side TP**3** defines the longer and more distal of the non-parallel sides, while side TP**4** defines the shorter and more proximal non-parallel side. Side TP**1** is therefore connected to sides TP**3** and TP**4**. When the clip is in the unlocked position as shown in FIG. **6***a*, and the buttress body **150** is fully extended away from the clip hinge **130** out in the most proximal position, the vertex TPX**1** of sides TP**1** and TP**4** lies approximately on or near the longitudinal axis L, and side TP**1** makes an angle α below the longitudinal axis, towards proximal jaw **142**, such angle α being, in one embodiment, approximately 30 degrees. As shown in FIG. **6***a*, the rounded laterally-spanning protuberance **156** extends substantially from side TP**3**.

The clip hinge **130** can also be a resilient hinge providing additional biasing force to maintain the inner clamping surfaces **131**, **132** of the legs towards a closed position. A span of each leg extending from the clip hinge **130** to its respective distal tip **123**, **124**, can be, in one embodiment of the present invention, at least 75% to 80% of an overall length of the clip. As shown in FIGS. **2***b* and **2***c*, the clip hinge **130** can define lateral bosses which extend laterally from the side surfaces of the clip legs, defining a bossed width or span which is greater than the clip width.

In the embodiment shown in FIGS. **1-15**, the clip hinge **130** is formed as a laterally extending bar **130***x* integrally formed with the first and second legs **101**, **102**, each leg being resiliently coupled to first and second transverse sides of said bar, the bar **130***x* further defining laterally spanning grooves **130***a* and **130***b* on longitudinally distal and proximal sides of the bar, respectively. These grooves **130***a* and **130***b* further enable the clip **100** to flex as pivoting about the lateral axis of hinge **130**, and further provide a resilient pivoting moment or force about said hinge.

Furthermore, in the embodiment shown in FIGS. **1-15**, flanges **191** and **192** extend longitudinally across respective outer surfaces of each of the first and second legs **101**, **102** which are on opposite sides to the inner clamping surfaces **131**, **132** of each respective leg, the flange **191** of the first leg **101** extending from the first jaw structure **141** to the distal end portion **121** of the first leg **101**, the flange **192** of the second leg **102** extending from the second jaw structure **142** to the distal end portion **122** of the second leg **102**. Each of the flanges **191**, **192** defines a transverse indentation **191***a*, **192***a* proximate the distal end portions **121**, **122** of the legs **101**, **102**. The flanges **191** and **192** provide a rigidity to legs **101** and **102**, respectively, such that said legs do not easily bend. Transverse indentations **191***a* and **192***a* provide a means for a clip applier to better actuate or grip the legs **101**, **102**.

The clip **100** further includes serrations, ridges, or teeth **181**, **182** on the inner clamping surfaces **131** and **132**, respectively, as shown in FIGS. **6***b* and **7***b*, and **9**, **10**, and **15***a*. The teeth or ridges **181**, **182** provide additional grasping means to better attach and clamp the clip **100** onto a vessel when closed. The teeth or ridges **181**, **182** are disposed to fit into complementarily arranged grooves **183** and **184** on the clamping surfaces **131** and **132**, respectively. The teeth **181**, **182** may have a slanted orientation, extending proximally, so as to better grip tissue. As best shown in FIGS. **6-6***a* and **7-7***a*, a pair of distal hook elements **194** and **195** may be disposed on the absolute distal tips of legs **101** and **102**, respectively, each hook **194** and **195** offset laterally with respect to each other to form a scissor-like configuration, such that each hook **194** and **195** fit into corresponding recesses **195***a* and **194***a*, respectively, on the distal tips of legs **102** and **101**, respectively. This mechanism provides means to further grip and contain tissue with the space between the clamping surfaces **131**, **132** when the clip **100** is applied to body vessel, as illustrated in FIGS. **19** and **20**.

The clip **100** may be in a range of sizes. As shown in FIG. **15**, an overall length "S**1**" of the clip **100** may be approximately 0.50 inches; the length "S**2**", between the intersection of transverse axis T and longitudinal axis L centered at clip hinge **130** and the distal tip of the clip, may be approximately 0.40 inches, and the radius of curvature of the inner mating or clamping surfaces **131**, **132** of the legs **101**, **102** may be approximately 3.0 inches. Such sizes and dimensions are given as an example, and it is understood that the clip may, in one or more embodiments of the invention, vary in size ranging from approximately 0.15 to 0.80 inches in overall longitudinal length, and from approximately 0.03 to 0.15 inches in lateral width. As one embodiment of the invention, the illustration of clip **100** in FIG. **15** is shown as a scaled magnification of actual size, and shows all the parts of the clip **100** in actual proportion to each other.

The instrumentation used to deploy the clips discussed herein may include a manually loaded device that can apply a single clip at a time, or an automatically fed, multi-clip applier. Both appliers can be endoscopic instruments suitable for use in laparoscopic surgery applications. In both cases the applier will clamp over the vessel to flatten the section to be ligated. The clip will then be opened, positioned over the vessel and closed. Once closed, a mechanism will engage the locking feature on the proximal end of the clips disclosed herein, to the to maintain the clamping pressure of the clip. A manual applier will load/apply a single clip at a time. An automatic applier will be able to load/apply multiple clips before the instrument has to be removed from the surgical site. The sequence of clip application is as follows:

1. The clip is presented in the partially closed condition.
2. A device, such as a set of applier jaws clamps down on the vessel or tissue to be ligated or clamped. The applier jaws have a channel down the center that is just large enough to allow the clip to fit in the channel
3. The clip is opened by pressing the proximal legs together lightly.
4. The clip is advanced over the vessel or tissue that is clamped within the jaws of the applier (the clip traveling in the channel area of the applier jaws).
5. Once fully advanced, the proximal legs are released and the clip springs back to the partially closed condition.
6. The proximal locking mechanisms discussed for the clip embodiments disclosed herein are actuated or pressed, causing the legs or 'clamping section' of the clips to close tightly on the vessel or tissue.

The various embodiments of the clips disclosed herein therefore can start in an as-molded state; can be opened further to better encapsulate the vessel; and can then be closed further (into a 3rd state). This process of opening and closing the clip can be repeated as needed, prior to locking. When closed and locked, the clip provides an active clamping force

which can also squeeze the vessel, which is beneficial if the vessel necroses and/or shrinks over time.

The various embodiments of the surgical clips of the present invention are preferably made of one or more polymer materials, such as, by example, acetyl homopolymer, but could also be made of a variety of other materials, including one or more metals, or a combination of metal and polymer or plastic. In selecting the material(s) used, the radiopacity of the clip can be "tuned" to a desirable level, or can be tuned to be radiopaque.

The various embodiments of surgical clips of the present invention are an improvement over the known polymeric surgical ligation clips, as well as standard metal clips. Among the resulting advantages of the surgical clip of the invention as disclosed herein are: the ability to deliver a larger clip through a smaller endoscopic instrument; the ability to place a clip on a vessel just like a prior art malleable and deformable metal clip, with no need for added dissection or cleaning around the vessel, but with greater retention force than metal clips, which results in a reduced risk of clips slipping off the vessels. The greater clip locking stability and clip retention force is accomplished by the locking feature applying an active biasing or clamping force as discussed above, versus the passive clamping action created by plastic deformation of malleable metal clips.

The following several paragraphs provide a brief description of several embodiments and refer to the FIGS. Later below a more in-depth description is provided and refers to not only the FIGS. but also specific reference characters.

The litigation clip applier can be split into three main sections for discussion. They are the distal end or shaft, the multistage transmission, and the handle.

One embodiment of the distal portion of the applier is made up of 12 parts. Two feeder rails, see FIG. **21**, two wedges, see FIG. **22**, two primary pushers see FIG. **23**, two final pushers, see FIG. **24**, inner and outer tubes, see FIGS. **25** and **26**, and two jaws, see FIG. **31**. When assembled the inner and outer tubes are concentric and both attach to the jaws. The outer tube has tabs with holes that the jaws fit into and rotate about. The inner tube connects to the jaws in a pocket that provides the cam surface to open and close the jaws, see FIGS. **27** and **28**. The inner tube acts as a push pull link to actuate the jaws, see FIGS. **19** and **20** for jaw actuation. The two feeder rails are assembled so that they make pockets to hold the clips, the number of clips to be held is determined by the ratio of the overall length of the applier and the size of the clip. The rails are spring loaded together and spread apart when the bosses on the clips pass through to the next pocket. The primary pushers ride on the sides of the feeder rails, the primary pusher has spring fingers that are spaced equidistant to match the pockets in the feed rail. When advanced they push the entire stack of clips forward to the next pocket in the feed rails. They also provide the push that allows the second clip to lock the first clip. The final pushers ride outside of the primary pushers and are what advanced the first clip over a vessel in the jaws of the applier. The final pushers also hold the first clip in place while the wedges retract. The wedges are just inside the feeder rails and are spring loaded together at the ends to open the first clip as it is advanced forward. The wedges also move forward into the jaws to cam the legs of the clip closed after it has fully advanced. The spring load for the wedges is provided by spring tabs in the outer tube that push down on the wedges. There is also a false clip that has two purposes, the first is to lock the last clip and the second is to pull on the cable that triggers the low clip indicator and last clip lockout. The false clip is advanced down the distal portion of the applier the same way the stack of clips is advanced. For actuation of the parts and clip advance/lock, see FIGS. **32-44**.

The proximal end of the applier, or applier handle, is made up of many parts that provide a user interface portion of the applier. Each of the distal end actuations are accomplished through the use of the proximal handle. The handle has a two piece outer shell which stages the internal actuating components and provides a bearing surface for a multi stage transmission to allow 360° continuous rotation of the distal end. There is a two piece rotation knob clamped onto the distal portion of the multi stage transmission which is shaped to facilitate the 360° continuous rotation of the distal end, see FIGS. **46-48**.

In one embodiment of the handle there are two triggers, both triggers rotate around the same center point, see FIG. **50**. The lower trigger actuates the jaws and the upper trigger actuates the clip delivery sequence. The lower trigger is attached to the multistage transmission through two mirrored linkages which have features that allow the trigger to lock down when the jaws are closed. This feature is an over center cam. The linkages also have an inner profile which allows them to drive the section of the multistage transmission that actuates the jaws while allowing the 360° continuous rotation. The return stroke of the lower trigger is accomplished through a return spring attached to a cable that wraps around the front of the trigger and based on a pin at the proximal side of the handle. There is a interlock on the upper trigger that locks the upper trigger until the lower trigger is pulled and locked down to ensure a clip is not prematurely delivered. The upper trigger is attached to the multistage transmission through a linkage which has and inner profile that drives the section of the multistage transmission that actuates the clip delivery mechanisms and also allows the 360° continuous rotation. The return stoke of the upper trigger is accomplished through a return spring attached to the back side of the trigger and based on a pin at the proximal side of the handle. For both the actuation and return strokes there is a one way pawl that limits the direction of the upper trigger until a full stroke is completed. There is also a low clip indication/last clip lockout that is actuated when the false clip moves down shaft. As the clips get low the cable pulls off of the drum. At the end of the cable is a crimped on ball that starts to pull on the lockout latch which begins to move the lockout lever. The top of the lockout lever has an indicator that shows through a window in the handle outer shells indicating low clips in one color and then indicates no clips left in another. When there are no clips left the lockout lever engages the ligate trigger and locks the trigger in place. The jaw trigger still functions see FIG. **50** for triggers and actuating components.

In a second embodiment of the handle, the trigger functions are reversed so that the upper trigger actuates the jaws and the lower trigger actuates the clip delivery mechanisms.

The distal portion of the applier is connected to the handle through the multi stage transmission, see FIGS. **49** and **50**. One embodiment of the transmission is made up of a two piece outer shell which acts as the bearing to allow the rotation of the distal end. Internal to the shell are features that guide the internal components during the actuation sequences of the applier. There are two jaw links that connect to the inner tube of the distal end and provide the grove for the inner features of the lower trigger linkages. The jaw links snap together and ride on the internal surface of the transmission shell. The area between the jaw links is open to allow for additional transmission parts. There are two center spindles that snap together and attach to the wedges, the outer surfaces provide a guide for the final pusher latch and the primary pusher latch. The final pusher latch and the primary pusher

latch move over the center spindles and are guided in slots on the outer shell of the transmission. Small pins move in and out of groves in the two pieces and the outer shell to achieve the appropriate timing for the clip delivery mechanisms in the shaft, see FIGS. **59-66** for the transmission assembly and FIGS. **67-76** for actuation sequence.

Another embodiment of the distal portion of the applier is made up of 10 parts. One outer tube, one inner tube, two jaws, one walking beam, see FIG. **77-79**, one walking beam pusher, see FIGS. **80** and **81**, one punch ring, see FIG. **82**, two punch doors with door wedges, see FIGS. **83** & **84**, and two clip advancers, see FIG. **85**. When assembled the inner and outer tubes are concentric and both attach to the jaws. The outer tube has tabs with holes that the jaws fit into and rotate about. The inner tube connects to the jaws in a pocket that provides the cam surface to open and close the jaws. The inner tube acts as a push pull link to actuate the jaws. When assembled the walking beam pusher rides in grooves on the walking beam. The punch ring is permanently fixed to the distal end of the walking beam and provides the attachment point for the punch doors. The punch doors are attached to the punch ring via a rivet or tabs that allow the doors to rotate. The doors are forced closed by a torsion spring or may be a plastic part that has spring like characteristics that keep the doors closed. On the underside of the punch doors are wedges that force the clip to open when the clip is pushed through the doors. The clip is pushed forward by a pair of clip advancers that ride on the outside of the walking beam and walking beam pusher. For actuation of the parts and clip advance/lock, see FIG. **86-97**. A cross-section of the distal end is shown in FIG. **98** for assembly reference.

The distal portion of the applier would be attached to a proximal handle with components that achieve the proper sequence to successfully apply a ligation clip. The following discussion refers to the FIGS. and specific reference characters.

FIG. **16** shows an applier **1000** in accordance with an embodiment of the invention. The applier **1000** is shown about to clamp a blood vessel or tissue **1002**. The applier **1000** includes jaws **1004**, a shaft **1003**, and a clamshell transmission housing **1007**. The applier **1000** also includes a clamshell housing **1009**, a handle **1011**, a ligate trigger **1013**, and a jaw actuating trigger **1015**.

FIGS. **17** and **18** shows a clip **100** after it has clamped a vessel or tissue **1002** via the applier **1000**. As shown in FIG. **18**, the clip **100** has the first **101** and second legs **102** locked in a clamping position over the vessel or tissue **1002**. The buttress body **150** on the clip **100** has moved forward and locked the legs **101** and **102** by interlocking the detent **157** into the notch **147**.

FIG. **19** shows the applier **1000** about to clamp a vessel or tissue **1002**. The upper jaw **1006** and the lower jaw **1008** are positioned to be above the vessel or tissue **1002**. FIG. **20** shows the jaws **1004** of the applier **1000** shut and thereby clamping the vessel or tissue **1002** with the jaws **1004**.

FIGS. **21-31** show various parts of the applier **1000**. FIG. **21** shows a feed rail **1010**. The feed rail **1010** has end projections **1014** and cut out slots **1012**. The cut out slots **1012** form slots that will be discussed in more detail later. FIG. **22** shows a wedge **1016**. While only one is shown in FIG. **22** in the applier **1000**, there are two wedges **1016** and they are identical or mirror images of each other. The wedges **1016** include a thicker portion **1018**, a slanted surface **1020** and define a U-shaped channel **1022**.

FIG. **23** shows a primary pusher **1024**. While only one primary pusher **1024** is shown in FIG. **23** there are two primary pusher **1024** that are identical or mirror images of each other in the applier **1000**. The primary pusher **1024** includes a flat portion **1026**, two rails **1028**, and several forked engagers **1030**. The forked engagers **1030** connect to the flat portion **1026** via a engager connector **1032**. The number of forked engagers **1030** may vary depending upon the length of the shaft **1003** (See FIG. **16**) and how many clips **100** are loaded in the applier **1000**. The forked engagers **1030** are used to move the clips **100** forward and will be discussed further below.

FIG. **24** shows a final pusher **1036**. The final pusher **1036** includes a pusher backing **1037**, two sets of pusher rails **1038**, a pusher engager connector **1040** and a final pusher forked engager **1042**. The final pusher forked engager **1042** will engage and push a clip **100** (not shown in FIG. **24**) as will be discussed later.

FIG. **25** shows an inner tube **1044**. The inner tube **1044** has T-shaped connecting structure **1046**, U-shaped channels **1048**, a top slot **1050** and guides **1052** in the top slot **1050**. FIG. **26** shows a outer tube **1054**. The outer tube **1054** provides the outer housing for the shaft **1003**. The outer tube **1054** has eye brackets **1056** defining holes **1058**. The outer tube **1054** also has leaf spring limbs **1060**. The leaf spring limbs **1060** extend into the interior of the outer tube **1054**.

FIG. **27** shows the jaws **1004** connected to the inner tube **1044**. The jaws **1004** have T-shaped structure holes **1064**. The T-shaped connecting structure **1046** of the inner tube **1044** fit into the T-shaped structure holes **1064** of the jaws **1004** and allow the jaws **1004** to pivot on the T-shaped structure **1046**. The jaws **1004** have jaw grooves **1062** for assisting in the engagement of the jaws **1004** with a vessel or tissue **1002**. The jaws **1004** also have pushing surfaces **1072**. When an object pushes against the pushing surfaces **1072** the jaws **1004** will pivot on the T-shaped structure **1046** to an opened position. FIG. **28** is an enlarged partial view of the jaws **1004** and the inner tube **1044**. The top jaw **1006** has a press point **1070** with the lower jaw **1008**. The cam surface **1066** on the inner tube **1044** is seen as well as the cam surface **1068** on the jaw **1006**. When an object presses on the press surface **1072** the cam surfaces **1066** and **1068** urge against each other as the jaws **1004** open. The cam surfaces **1066** and **1068** also urge against each other as the jaws **1004** close.

FIG. **29-31** show various views of the top jaw **1006**. The top jaw **1006** is the same as or a mirror image of the low jaw **1008**. The top jaw **1006** has T-shaped structure holes **1064**, jaw hinge pins **1074** and hinge pin caps **1076**. The hinge pin caps **1076** have been removed from one of the jaw hinge pins **1074** for clarity, usually there are hinge pin caps **1076** on each hinge pin **1074**. The top **1078** and the bottom **1080** of the top jaw **1006** are shown.

FIG. **32** is a side isometric view of a part of the applier **1000**. The inner **1044** and outer tubes **1054** are cut away to better show interior parts. The jaws **1004** are clamped on a vessel or tissue **1002**. The clip **100** has not yet moved forward into the jaws **1004** so that it can clamp the vessel or tissue **1002**. The end projections **1014** of the feed rail **1010** are visible. The slot cut outs **1012** make a space for the jaw hinge pin **1074** to reside. In the position shown in FIG. **32** the final pusher forked engager **1042** is spaced from the hinge pin **1074** on the clip **100**. The final pusher engager connector **1040** connects the final pusher forked engager **1042** to the final pusher back **1037**. The clip **100** is in a somewhat open position and the leaf spring limbs **1060** are not engaging the clip **100**. The wedges **1016** can also be seen.

FIG. **33** is similar to FIG. **32** but shows the top feed rail **1010** cut away. The clip **100** and the top wedge **1016** can be seen along with the final pusher **1036**. In FIG. **34**, a similar view of the applier **1000** is shown but the top of the final

pusher **1036** is cut away. The clip **100** can be seen. A second clip **1252** can be seen in position behind the first clip **100**. The primary pusher **1024** can be seen. Once the first clip **100** is applied, the second clip **1084** will move forward and become the first clip **100** (from the point of view of position) as will be explained later.

FIGS. **35-44** will illustrate in cross section views the application sequence and forward movement of the clips **100**, **1084** in the applier **1000**. The jaws **1004** are clamped on the vessel or tissue **1002**. The end projections **1014** are visible forward the clip **100**. The top wedge **1016** is also visible. The final pusher **1036** is cut in half for clarity. A second clip **1084** may also be seen with the primary pusher **1024** behind the second clip **1084**. FIG. **35** shows an initial condition of the various parts of the applier **1000** when the jaws **1004** are first clamped on the vessel or tissue **1002**.

FIG. **36** shows the start of ligation. The wedges **1016**, the primary pushers **1024** and the final pusher **1036** begin to move. The feeder rails **1010** spread apart to allow the boss **1082** on the clip **100** to pass through. The primary pusher **1024** engages the second clip **1084**. In FIG. **37**, the wedges **1016** open the clip **100** and by a camming action between the thicker portion **1018** of the wedge and the clip **100**. The final pusher **1036** advances the open clip **100** into the jaws **1004** and over the vessel or tissue **1002**. The primary pusher **1024** advances the second clip **1084** (and any other clips that may be located behind the initial clip **100**). FIG. **38** shows the wedges **1084** advancing by action of the primary pusher **1024**. The wedges **1016** advance to close the clip **100** onto the vessel or tissue **1002**.

As shown in FIG. **39** the second clip **1084** advances by action of the primary pusher **1024** into buttress **150** of the first clip **100** (sometimes referred to as the initial clip **100**). The buttress **150** is moved by the second clip **1084** to the point that the detent **157** fits into the notch **147** thereby locking the first clip **100** onto the vessel or tissue **1002**. In FIG. **40**, the wedges **1016** retract, however, the feeder rails **1010** (partially cut away in FIG. **40** and are better shown in FIG. **35**) stay together and thus keep the second clip **1084** from retracting. The final pusher **1036** stays in place to keep the initial clip **100** in a forward position. In FIG. **41** the wedges **1016**, the primary pusher **1024** and the second clip **1084** (and any other clips behind the initial clip retract).

As shown in FIG. **42** the second clip **1084** stops in the slot **1012** (best shown in FIG. **32**) in the feeder rails **1010**. The wedges **1016**, primary pushers **1024** and the final pusher **1036** begin to retract. FIG. **43** shows the parts returning to an initial or start condition. The thicker portion **1018** of the wedges **1016** open top **101** and bottom **102** legs of the second clip **1084**. The first clip **100** was released and exited the applier **1000** when the jaws **1004** were opened. The second clip **1084** now becomes the first clip **100** and the cycle starts over.

FIG. **44** shows how that final clip **1086** is applied. The cycle is substantially the same as described above for applying a clip **100** but a false clip **1088** performs the function of locking the last clip **1086**. FIG. **45** shows the false clip **1088**. The false clip **1088** includes longitudinal ridges **1090**, a butting face **1092**, a boss **1094**. These features perform similar functions as the similar features found on the actual clip **100**. The false clip **1088** also has a hole **1096**.

FIGS. **46-58** show and describe how the applier receives inputs from a user and provides those inputs to the transmission **1098**. The transmission **1098** receives the inputs and converts them to motions to the parts that act on the clips **100**, **1084**, **1086**. FIGS. **46** and **47** show a part of an applier **1000** having a shaft **1003**, a transmission housing **1007**, a clam shell housing **1009**, and handle **1011**, a ligate trigger **1013** and a jaw trigger **1015**. While claim shell housings may be described herein, other types of housings may be used.

FIG. **48** shows and exploded view of part of the applier and some of the internal mechanisms. The clamshell housings **1009**, the handle **1011**, the transmission housing **1007**, the shaft **1003** and the transmission **1098** as well as other parts that will be described in more detail can be seen. FIGS. **49** and **50** shows many of the internal components in more detail. The transmission **1098** has a jaw link input **1110** having a jaw link input groove **1112**, a center spindle **1114** and a second input **1116** having a second input groove **1118**. An upper grasper lever pin **1102** fits into the jaw link input groove **1112** and moves to provide an input to the transmission **1098**. The upper grasper lever pin **1102** also fits into grasper lever holes **1106** and is controlled by the grasper levers **1100**. The grasper levers **1100** have grasper lever slots **1108** in which the lower grasper lever pin **1104** rides. In some embodiments of the invention, the lower grasper lever pin **1104** fits into the jaw trigger pin holes **1154** on the jaw trigger **1015**. The grasper levers **1100** and thus the input **1110** is controlled by the grasper/jaw trigger **1015**.

The ligate lever **1120** has ligate lever slots **1122** in which the ratchet plate pin **1160** resides. The ratchet plate pin **1160** also fits in the ratchet plate pin holes **1162** on the ratchet plates **1158**. Thus, the ligate lever **1120** is controlled by the ratchet plates **1158**. The ligate lever **1120** has ligate lever trunnions **1124** which fit into the second input groove **1118** in the second input **1116**. Thus, the ligate lever **1120** controls the second input **1116**. The ratchet plates **1158** have ratchet teeth **1166** and disengaging cams **1168** that interact with forward **1126** and rearward **1128** facing pawls. The pawls **1126**, **1128** ride on a pawl shaft **1130** that is connected by a pawl spring **1132** connected to a spring anchor **1134**. It is noted that the inputs **1110** and **1116** are circular and the features (i.e. pins) that control the inputs may be rotated 360° about the inputs **1110** and **1116** so that a user can manipulate the triggers **1013** and **1015** from a rotated position with respect to the transmission **1098** and jaws **1004**. FIGS. **51-58** show the pawl mechanism and its accompanying discussion will explain how the pawl mechanism works.

Springs **1146** and **1148** are used to bias the triggers **1013** and **1015** to a position against the handle **1011**. The triggers **1013** and **1015** and the ratchet plates **1158** all pivot about the same hole **1156**. A pivot pin may be provided or trunnion on the housing **1009** may provide a pivot. In some embodiments, a spring extension **1150** may be used to connect either or both of the springs **1148** and **1146** to a desired feature. In some embodiments the spring extension **1150** may attach to the pin **1152** which may fit in holes **1164** in the ratchet plates **1158**. A low clip indicator spring **1136** may fit around a low clip indictor anchor **1138**. The low clip indicator **1136** is connected to the low clip indicator **1140**, which in turn is connected to the last clip lock out **1142** and grommets **1144**. The low clip indicator **1140** may help a user to know that the amount of clips in the applier are low. The last clip lockout **1142** may prevent the user from using the applier **1000** when there are no more clips in the applier **1000**. FIG. **50** shows a trigger lock **1170**. The trigger lock **1170** has a trigger lock groove **1172**. A trigger release **1178** has a detent **1174** that fits into the trigger lock groove **1172**. A trigger lock spring **1176** urges the trigger release **1178** toward the trigger **1013**.

FIG. **51** shows an initial condition where the triggers **1013** and **1015** (not well shown in FIG. **51**) are in a position against the handle **1011** (see FIG. **16**) The triggers **1013** and **1015** and the ratchet plates **1158** will move as shown and described. The teeth **1166** on ratchet plates **1158** are not engaged with either the forward facing **1126** or the rearward facing **1128** pawl.

The pawl anchor is attached to the housing **1009** (a front housing piece has been removed to the pawl mechanism may be seen). The disengaging cam **1168** has disengaged the reward facing pawl **1128** from the teeth **1166**. FIG. **52** shows that the rearward facing pawl **1128** is disengaged with the teeth **1166** and the forward facing pawl **1126** is engaged with the teeth **1166** during the pull of the ligate trigger **1013**. In FIG. **53**, the forward facing pawl **1126** is engaged with the teeth **1166** the rearward facing pawl **1128** is engaged. In FIG. **54** the disengaging cam **1168** disengages the pawl **1126** and engages the pawl **1128** with the teeth **1166**. FIG. **55** shows the pawl **1126** disengaged by the disengaging cam **1168** and the cam **1168** engaged. FIG. **56** shows that during the return of the trigger, the rearward facing pawl **1128** stays engaged with the teeth **1166** while the forward facing cam **1126** remains disengaged with the teeth **1166** on the ratchet plates **1158**. FIG. **57** is similar to FIG. **51** as the triggers **1013** and **1015** return to the initial position proximate to the handle **1011**. FIG. **58** is a side view of the pawl **1126** and ratchet plate **1158** in the position shown in FIGS. **51** and **57**.

FIGS. **59-66** show the parts and the layout of the parts of the transmission **1098** various parts will be removed from the FIGS. to show interior parts. FIG. **59** is an exploded view of the transmission **1098**. FIG. **59** shows the outer rotating housing **1180**, **1182** of the transmission. The outer rotating housing **1180**, **1182** may be a clamshell housing. Jaw link actuators **1184** and **1186** define the jaw link input **1110** and jaw link input groove **1112**. The jaw link actuators **1184** and **1186** have attaching structure **1188** for attaching to parts that will be described later. Within the jaw link actuators **1184**, **1186**, are final pusher latches **1190**, **1192**. The final pusher latches **1190**, **1192** also have attaching structure **1194** for attaching to other parts as will be described later.

A primary pusher latch **1202** (or latches, many of the parts may be referred to in the singular or plural form as many are made of two pieces. However multiple piece are not required to be referred to in the plural form) may have attaching structure **1200** for attaching to other parts as will be described later. The primary pusher latch **1202** may include attaching pin grooves **1198** for attaching pins **1196**. The center spindle **1114** is attached to the second input **1116** which defines the second input groove **1118**. The center spindle **1114** has pin grooves **1218**.

FIG. **60** shows the transmission **1098** with the outer rotation housing **1180** in place and the center spindle **1114** extending from the housing **1182**. In FIG. **61**, one of the housing members **1182** has been removed. The housing **1180** is still present. The jaw link actuators **1184**, **1186** are visible. FIG. **62** shows the transmission **1098** with the jaw link actuators **1184**, **1186** removed. The final pusher latches **1190**, **1192** and the primary pusher latches **1202** are visible along with the attaching pins **1196**. FIG. **63** has the housing **1180** removed. The final pusher latches **1190**, **1192** and the primary pusher latches **1202** are visible along with the attaching pins **1196** in the attaching pin grooves **1198**. FIG. **64** shows the transmission **1098** with the final pusher latches **1202** and pins **1196** removed. The primary pusher latch **1202** is visible. In the transmission **1098** shown in FIG. **65** the final pusher latch **1202** is removed.

FIG. **66** shows the transmission **1098** with the center spindle **1114** removed. The wedges **1016** are shown with wedge connection brackets **1204** where the wedges **1016** connect to the transmission **1098** via the center spindle **1114**. The connection point **1206** where the primary pusher **1024** connects to the transmission **1098**. The connection points **1208**, **1210**, and **1212** are shown for connecting the transmission **1098** to the final pusher **1036**, the inner tube **1044**, and the feed rail **1010** respectively are shown. The outer tube **1054** can also be shown. The connections between the transmission **1098** and the various elements are not limited to what is shown. Any suitable means may be used. One of ordinary skill in the art may, after reviewing this disclosure, conceive of various ways to connect these features to the transmission **1098**.

FIGS. **67-76** are cross sectional views of the transmission **1098** at various positions. The movement of the transmission components will cause the components they are connected to move the clip **100** (not shown in these FIGS.) to various positions and/or orientations within the applier **1000**. The components the transmission is manipulating are generally not shown in FIGS. **67-76** but they are shown and described with respect to other FIGS. At FIG. **67**, transmission **1098** is in a position to cause the jaws **1004** to be in an open position. The second input **1116** is extended away from the transmission **1098**. The jaw link input **1110** is spaced away from the outer housing **1180** of the transmission **1098**. The final pusher latch **1190** and the primary pusher latch **1202** may be seen. At FIG. **68** the jaw link input **1110** has moved toward, and contacts the housing **1180**. The jaws **1004** are in a clamped position. The center spindle **1114** and second input **1116** are still extended. In FIG. **69** the clip **100** is starting to advance. The second input **1116** is moved slightly toward the jaw link input **1110**.

In FIG. **70**, the first clip **100** is advanced to be over the vessel or tissue **1002** by the final pushers **1036** and the wedges **1016** advance. The second clip(s) **1084** are advanced by the primary pushers **1024**. The final pusher latch **1190** has moved such that the attaching pins **1196** are aligned with pin notches **1214** in the outer housing **1180**. The attaching pins **1196** can move out of the pin grooves **1218** in the center spindle **1114** (see FIG. **59**) and into the into the pin notches **1214** and thus unlock the final pusher latch **1190** with the center spindle **1114**. Likewise, the primary pusher latch **1202** has moved so that the attaching pins **1196** are aligned with the pin slot **1216** in the outer housing **1180**. As a result, the pins **1196** can move out of the pin grooves **1218** in the center spindle **1114** and into the pin slot **1216** and thus unlock the primary pusher latch **1202** from the center spindle **1114**. The primary pusher latch may move along the center spindle the length of the pin slot **1216**.

In FIG. **71** the transmission **1098** is shown where the wedges advance to close the first clip **100**. The second input **1116** moves inward causing the center spindle **1114** to move inward. The pins **1196** are moved to the pin notches **1214** and pin slots **1216** in the housing **1180**. In FIG. **72**, the clip **100** is latched. The primary pushers **1036** advance the second clip **1084** (or false clip **1088**) to lock the first clip **100**. This is accomplished by moving the second input **1116**/center spindle **1114** further into the transmission **1098**. The pins **1196** stay in the pin notches **1214** and pin slot **1216**. In FIG. **73** the transmission **1098** is shown where the wedges **1016** begin to retract. The center spindle **114** moves out of the transmission **1098**. The pins **1196** are still in the pin notches **1214** and pin slots **1216**. The final pusher latch **1190** and the primary pusher latch **1202** are unchanged from FIG. **72**. In FIG. **74**, the center spindle **1114** continues to move out of the transmission **1098**. The pins **1196** still in the pin notches **1214** and slots **1216**. The final pusher latch **1190** is unchanged from FIG. **72**, but the primary pusher latch **1202** has moved back.

In FIG. **75** the position of the transmission **1098** is shown where the final pusher **1036** retracts and other parts also retract. The pins **1196** are once again aligned with the pin grooves **1218** and the final pusher latch **1190** and the primary

pusher latch **1202** have moved back taking the pins **1196** out of alignment with the pin notches **1214** and pin slot **1216**.

FIG. **76** shows the transmission **1098** back in the start position. The final pusher latch **1190** and the primary pusher latch **1202** are move back and the center spindle **1114** is full extracted. The transmission **1098** shown in FIG. **76** is similar to the transmission **1098** shown in FIG. **67**.

A second embodiment is shown in FIGS. **77-98** this embodiment is similar to the applier **1000** described above, but it uses a slightly different system to move the clips **100**, **1084** along. Where the description of the second embodiment is silent, as to specific parts, the second embodiment may be assumed to be similar to the first embodiment with respect to the not described features.

FIGS. **77-85** show individual elements. How these elements fit together and operate are shown and described with respect to FIGS. **86-98**. FIGS. **77-79** show a walking beam **1220**. The walking beam **1220** includes pusher arms **1222** mounted to a side **1224** of the walking beam **1220**. The walking beam **1220** also has brackets **1226** mounted to one side. FIGS. **80-81** show a walking beam pusher **1228** which includes pusher arms **1230**.

FIG. **82** shows a punch ring **1231**. The punch ring **1231** includes U-shaped protrusions **1232** and connecting holes **1234**. FIG. **83**, shows a punch door **1236** that mounts to the punch ring **1231**. The punch door **1236** includes eye brackets **1238**, holes **1240** in the eye brackets **1238** and slots **1242**. FIG. **84** shows a door wedge **1244**. FIG. **85** shows a clip advancer **1246** having a pushing member **1248**.

FIG. **86** shows the elements of the second embodiment fit in an outer tube **1054**. The position of the element is an initial or start position. The jaws **1004** are fit onto the outer tube in a similar manner as described with respect to the first embodiment. Door pins **1250** are shown connecting the punch doors **1236** with the punch ring **1231**. A clip **100** is shown behind the punch doors **1236**.

FIG. **87** shows the clip advancer **1246** pushing the first clip **100** through the punch ring **1231** and punch doors **1236**. The clip opens by virtue of a camming action between the wedges **1244** and the clip **100** passing by the wedges **1244**. FIG. **88** shows the walking beam **1220** and clip advancers **1246** moving forward toward the jaws **1004** to partially advance the clip **100** over the vessel or tissue **1002** (not shown in FIG. **87**.). In FIG. **89** the walking beam **1229** has stopped. The clip advancers **1246** push the clip **100** the final distance into the jaws **1004**. The clip **100** is pushed through the punch doors **1236** and wedges **1244**. The punch doors **1236** closed as they are spring loaded to do so. In FIG. **90**, the clip **100** is fully in the jaws **1004** and the punch doors **1236** are closed behind the clip **100**. In FIG. **91**, the walking beam **1220** advances to lock the clip **100**. The walking beam **1220** has moved forward and presses the punch doors **1236** against the buttress body **150** of the clip **100** causing the detent **157** to fit and lock into the notch **147**. In FIG. **92**, the walking beam **1220**, the clip advancers **1246** have returned to the start positions. The second clip **1084** and any other clips have advanced one position by the stationary walking beam pusher **1228**. The clip **100** may be released when the jaws **1004** are opened.

FIGS. **93-97** illustrate the process described above but with some of the components removed for clarity. In FIG. **93**, clip **100** starts to advance by the pusher arm **1230** of the walking beam pusher **1228** pushing against the second clip **1084**. The brackets **1226** on the walking beam **1220** are shown. The brackets **1226** allow the walking beam pusher **1228** to slidably connect to the walking beam **1220**. The punch ring **1231** is visible and the punch doors **1236** are shown on the punch ring **1231**. In some embodiments of the invention, the punch doors **1236** connect to the punch ring **1231** by hinge pins **1250** in the holes **1234** in the punch ring **1231** and holes **1240** in the eye brackets **1238** on the punch doors **1236**.

FIG. **94** shows the clip **100** partially extending through the punch doors **1236**. The pusher arm **1230** of the walking beam pusher **1228** is advancing the clip **100**. In FIG. **95** the clip **100** is opened by the wedges **1244** as the clip **100** passes through the doors **1236**. The pusher arm **1230** passes though the U-shaped protrusion **1232** of the punch ring **1231**. In FIG. **96** The clip **100** has extended through the punch doors **1236**. The pusher arm **1230** passes though the U-shaped protrusion **1232** of the punch ring **1231**. In FIG. **97** the walking beam **1220** moves forward, but the walking beam pusher **1228** remains stationary. The forward movement of the walking beam **1220** causes the punch doors **1236** to press against the buttress body **150** and rotate the buttress body **150** to lock as the detent **157** interlocks with the notch **147**. Thus, the clip **100** is locked in the closed position.

FIG. **98** is an end view of the applier **1000** where the punch doors **1236** are opened. The outer tube **1054** may be seen. The door wedges **1244** are shown in the punch ring **1231**. The U-shaped protrusions **1232** are also visible. The brackets **1226** on the walking beam **1220** holding the walking beam pusher **1228** are also visible.

FIGS. **99-108** show various trigger **1013** and **1015** positions that may occur while the applier **1000** is performing various steps.

In another embodiment, a different clip **2000** and adapter **2040** is used. This clip **2000** and adapter **2040** is shown and described in FIGS. **109-113**. FIG. **109** shows a side view of the clip **2000**. The clip **2000** includes an upper leg **2002** and a lower leg **2004**. Both legs **2002** and **2004** include teeth **2006** and grooves **2007**. The upper leg **2002** includes an upper front end **2008** the lower leg **2004** includes a lower front end **2010**. The upper front end **2008** includes an upper slanted edge **2012** and the lower front end **2010** includes a lower slanted edge **2014**. The upper leg **2002** and the lower leg **2004** pivot about a hinge portion **2016** which is part of a body portion **2018**.

The body portion **2018** includes a locking void **2020**. The clip **2000** is locked by moving a buttress **2022** into the locking void **2020**. The buttress **2022** includes a buttress void **2024**. The body portion **2018** includes locking wings **2026**. The locking wings **2026** help retain the buttress **2022** into the locking void **2020** when the clip **2000** is in a locking position. The buttress void **2024** includes locking interior surfaces **2030**. The buttress **2022** includes locking exterior surfaces **2032**. When the buttress **2022** is in the buttress void **2024**, the locking interior surfaces **2030** and the locking exterior surfaces **2032** will be in contact with each other.

The buttress **2022** is attached to the body portion **2018** and the connectors **2034**. The connectors **2034** are resilient and will flex to permit the movement of the buttress **2022** with respect to the body portion **2018**. The connectors **2034** are equipped with projections **2036**. The projections **2036** are useful when the clips **2000** are arranged in an automatic applier in a nose to tail fashion. In such an instance, the upper front end **2008** and lower front end **2010** of a clip **2000** behind a first clip **2000** will engage the projections **2036** of the clip **2000** in front.

FIG. **110** illustrates a top view of the clip **2000**. The upper leg **2002** and the upper front end **2008** are visible. The connector **2034** connecting the buttress **2022** and having the projection **2036** is also shown in FIG. **110**.

FIG. **111** illustrates an isometric view of the clip **2000**. The upper leg **2002**, the lower leg **2004**, the grooves **2007**, and teeth **2006** are visible. The lower slanted edge **2014** can also

be seen. The hinge portion **2016**, the buttress void **2024**, and the buttress **2022** are also visible in the isometric view shown in FIG. **111**.

FIGS. **112** and **113** illustrate the clip **2000** clamping onto a vessel **2038**. The grooves and teeth are not shown and are removed for clarity in FIGS. **112** and **113**. The vessel **2038** is clamped between the upper leg **2002** and the lower leg **2004**. The buttress **2022** has been moved into the buttress avoid **2024** causing the locking interior surfaces **2030** and a locking exterior surfaces **2032** to be in contact with each other. Movement of the buttress **2022** into the buttress avoid **2024** has caused the upper leg **2002** and the lower leg **2004** to be locked in a closed position. It will be appreciated that closing of the clip **2000** will cause the hinge portion **2016** to rotate thereby enlarging the buttress avoid **2024** and allowing the buttress **2022** to be pushed or moved into the buttress void **2024** thereby locking the clip **2000** in the closed position. Once the clip **2000** is in the closed position the vessel **2028** is clamped.

FIG. **114** illustrates an automatic applier **2040**. The automatic applier **2040** includes jaws **2042**. The jaws **2042** including upper jaw **2044** and a lower jaw **2046** an outer tube assembly **2048** is located between the jaws **2042** and a handle assembly **2050**. The handle assembly **2050** includes a handle **2052** and actuator **2054**. The actuator **2054** functions and acts similar to a trigger and is pivotally connected to the handle assembly **2050**. The handle assembly **2050** also includes a body **2056** and a rotator **2058**. The rotator **2058** is configured to allow a user to rotate the rotator **2058** which will thereby rotate the outer tube assembly **2048** and the jaws **2042**. Therefore the jaws **2042** can be oriented or rotated 360° to any orientation desired by a user. The automatic applier **2040** includes a distal end **2060** which includes the jaws **2042** and a proximal end **2061** which includes the handle assembly **2050**.

FIG. **115** illustrates a portion of the distal end **2060**. The outer tube assembly **2048** includes bosses **2062**. The bosses **2062** define holes **2064**. Jaw projections **2066** extend from the jaws **2044** and **2046** outwardly through the holes **2064**. The jaws **2044** and **2046** pivot about the jaw projections **2066** which pivotally connected jaws **2044** and **2046** to the outer tube assembly **2048**. The jaws **2042** are shown in an open condition and contain a clip **2000**. The jaws **2042** have approached flesh or a blood vessel **2038** but have not yet contacted it.

FIG. **116** illustrates the distal end **2060** and shows the jaws **2042**, **2044**, **2046** clamped on the flesh or vessel **2038**. A portion of the clip **2000** can be seen within the jaws **2042**. Closing the jaws **2042** is caused the clip **2000** to also be closed.

FIG. **117** is an exploded isometric view of the distal end **2060**. The outer tube assembly **2048** is shown along with the top jaw **2044** and lower jaw **2046**. Both of the jaws **2042** are identical parts and some embodiments of the invention. In other embodiments they can be slightly different or mirror images of each other. Each jaw **2044** and **2046** includes a jaw projection **2066** that extends outward and away from the jaws **2044** and **2046**. The jaw projections **2066** extend into the holes **2064** defined by the bosses **2062** and the outer tube assembly **2048**. The jaws **2044** and **2046** also include a jaw arm **2068**. The jaw arm **2068** defines an inward projecting a projection **2070**. It is the inward pointing projection **2070** that fits within the actuation slots **2082** found on the feed tube **2076**. By moving the feed tube **2076** in a distal or proximal direction, the inward projections **2070** on the jaws **2046** and **2044** pivot and cam within the slots **2082** to open and close the jaws **2042**.

The feed tube **2076** further contain slots **2078** and spring fingers **2080** fit within the slots **2078**. The spring fingers **2080** are useful in preventing clips **2000** (not shown in FIG. **117**) from moving in a proximal direction at undesired times. The feed tube **2076** stores a stack of clips **2000** which will be discussed further below. The clip lock arm **2072** includes a clip engaging portion **2074**. The clip engaging portion **2074** fits through one of the slots **2078** in the feed tube **2076**. The clip engaging portion **2074** is configured to move axially so that the clip engaging portion **2074** will engage and lock a clip **2000** as will be discussed further below.

A clip advance arm **2084** is equipped with pinchers **2086**. The clip advance arm **2084** also is configured to move axially and performs several functions. For example, it moves a clip **2000** forward into the jaws **2042** and also opens and closes the clip **2000** by action of the pinchers **2086** acting upon either the legs **2002**, **2004** (to close the clip **2000**) or on the locking wings **2026** and/or connectors **2034** to open the clip **2000**. When assembled, the feed tube **2076**, the clip locked arm **2072**, and the clip advance arm **2084** are all fit with in the outer tube assembly **2048**.

FIG. **118** is a partial cutaway view of the outer tube assembly **2048** and feed tube **2076** containing a stack of clips **2000**. Each clip **2000** has its upper and lower legs **2002**, **2004** pushing on the projections **2036** of the clip **2000** in front of it. A clip stack pusher **2088** pushes on the projections **2036** of the last clip **2000** of the clip stack. This clip stack pusher **2088** is spring-loaded and has a clip advance rod **2090** surrounded by a spring **2092**. The spring **2092** urges the clip stack pusher **2088** in a distal direction thus urging the clips **2000** also in a distal direction. Spring **2092** may urge against an internal portion of the handle assembly **2050** as can be appreciated by one of ordinary skill the art after viewing this disclosure.

FIG. **119** shows the distal portion **2060** including the upper jaw **2044** and the lower jaw **2046**. The jaws **2044** and **2046** are open and about to close over a tissue or blood vessel **2038**. A clip **2000** is shown to be in the jaws **2044** and **2046** and is also in the open position. The pinchers **2086** of the clip advance arm **2084** have moved forward and are contacting the locking wings **2026** and connectors **2034** of the clip **2000**. The pinching pressure placed on the connectors **2034** biases the jaws **2044** and **2046** to be open. The outer tube assembly **2048** is partially cutaway to expose internal components. The clips **2000** contained within the outer tube assembly **2048** are also shown.

In FIG. **120** the distal portion **2060** is illustrated again in a cutaway view. The jaws **2044** and **2046** are now in a closed position clamping the tissue or blood vessel **2038**. In order for the jaws **2044** and **2046** to close, the feed tube **2076** has moved to a proximate position. However the feed tube **2076** is not shown in FIG. **120**. The clip **2000** and is also in the clamp position and the connectors **2034** of the clamp are flexing the pinchers **2086** of the clip advance arm **2084**. The flex marks **2096** on the pinchers **2086** illustrates this. The broken line region **2094** of the pinchers **2086** also illustrates the interference between the clip **2000** and the pinchers **2086**. As a result of this interference, the clip **2000** and the pinchers **2086** will flex.

FIG. **121** shows the advance arm **2084** moving back to a proximal position to engage a second clip **2000**. Again, the broken line region **2094** represents the interference fit between the clip **2000** and the pinchers **2086** of the clip advance arm **2084**. Both the clip **2000** and the pinchers **2086** will flex to accommodate the interference. The second clip **2000** is prevented from moving back in a proximal direction by the rearward movement of the pinchers **2086** by the spring fingers **2080** (best shown in FIG. **117**) on the feed tube **2076**.

The clip locked arm **2072** starts to advance toward the clip **2000** in the jaws **2042**. The clip **2000** and the jaws **2042** are clamped onto the vessel **2038**, however the clip **2000** is not yet locked in the clamping or closed position.

FIG. **122** illustrates the distal end **2060** cutaway view. The clip advance arm **2084** has moved fully back or in the full proximal position and is now pinching the connectors **2034** and/or locking wings **2026** thereby urging the clip **2002** to move to an open position. Broken line region **2094** on the pinchers **2086** illustrates interference fit between the pinchers **2086** and the clip **2000** and the flex portion **2096** of the pinchers **2086** also illustrates stress on the pinchers **2086** to open. Thus the pinchers **2086** and the clip **2000** will flex to accommodate this interference fit. The clip lock arm **2072** has moved distally forward and has engaged and moved the buttress **2022** to push the buttress **2022** into the locking void **2020** to lock the clip **2000** onto the vessel **2038**.

FIG. **123** illustrates the distal portion **2060** in a cutaway view. The feed tube **2076** pushes forward or distally thereby opening the jaws **2042**, **2044**, **2046** to release the locked clip **2000** and vessel **2038**. The clip lock arm **2072** returns to its initial position. The clip advance arm **2084** remains in its pulled back or proximal position. The pinchers **2086** and the locking wings **2026** of the second clip **2000** are in an interference fit as indicated by the broken line section **2094**. Thus the clip **20** and the pinchers **2086** will flex to accommodate this fit. The buttress **2022** is still in the locking void **2020** causing the clip **2000** now exiting the jaws **2042** to remain locked on the vessel **2038**.

FIG. **124** illustrates the distal portion **2060** in a cutaway view. The clip **2000** and vessel **2038** are now clear of the jaws **2042** and are therefore not shown in FIG. **124**. The clip advance arm **2084** now pushes the next clip **2000** distally or forward into the jaws **2042**. The jaw projection **2066** of jaw **2046** is shown, as well as part of the feed tube **2076** and the actuation slots **2082** containing the actuation projection **2070** attached to jaw **2044**.

FIG. **125** illustrates the distal portion **2060** in a cutaway view. The clip advance arm **2084** moves forward or distally to push the clip **2000** into the jaws **2042**. At the same time, the pinchers **2086** apply force on to the locking wings **2026** and connectors **2034** to cause the clip **2000** to open as it enters the jaws **2042**. As the clip advance arm **2084** moves forward or distally, the clips **2000** and the clip stack move forward under the spring tension from the clip stack pusher **2088** (best shown in FIG. **118**).

FIG. **126** illustrates the distal portion **2060** in a cutaway view. The second clip **2000** and is fully advanced into the jaws **2042** by the pinchers **2086** of the clip advance arm **2084**. The connectors **2034** are under pinching pressure from the pinchers **2086** causing the clip **2000** to be an open position. The upper slanted edge **2012** of the clip **2000** is fit into a void or pocket that is defined at least in part by the slanted edge **2098** of the upper jaw **2044**. Similarly the lower slanted edge **2014** of the clip **2000** has fit into a void or pocket defined at least in part by, the slanted edge **2098** of lower jaw **2046**. By retaining the clip **2000** in this way, the clip **2000** can be manipulated without coming out of the jaws **2042** at undesired times.

FIG. **127** is an isometric view, FIG. **128** is a side view, FIGS. **129**A and **129**B are front and rear views of a clip pusher **2100** in accordance with another embodiment of the invention. FIGS. **127-138** illustrate a variation of the embodiments described above. The embodiment shown in FIGS. **127-138** is very similar to the embodiments described above and differ in geometry and in operation as described below. Where features are not described it may be assumed that the embodiment operates in a manner similar to that described above unless the FIGS. show otherwise.

The clip pusher **2100** includes a spring arms **2102** and projections **2104** which may aid in moving the clip pusher **2100** through the feed tube **2076**. The projections **2104** may include pushing surfaces **2106**, which may be configured to push a clip **2000** forward. The clip pusher **2100** includes spring fingers **2108** terminated with projections **2110**. In some embodiments of the invention, the projections **2110** aid in limiting the movement of the clip pusher **2100** when it is desired for the clip pusher **2100** to remain stationary. In some embodiments of the invention, at certain times, the projections **2110** will be moved inward by flexing the spring fingers **2108** when it is desired to move the clip pusher **2100**. In some embodiments, the body **2112**, the projections **2110**, the spring fingers **2108**, the projections **2104**, and the spring arms **2102** may be made of a single material and are unified. In other embodiments, they may be made of separate parts. FIG. **129**B illustrates a hole **2114** located in the body **2112** for receiving a clip advance rod **2090** (best shown in FIG. **118**).

FIG. **130** is an isometric, cutaway view of the distal end **2060** according to another embodiment. The feed tube **2076** is shown having slots **2078**. The projection **2110** on the spring finger **2108** has stopped the clip pusher **2100** from further moving distally or forward. Thus, when there are no clips **2000** in the feed tube **2076**, the clip pusher **2100** will move partially into the jaws **2042** but will be stopped by the projections **2110** (one on each side). The clip advance rod **2090** can be seen attached to the clip pusher **2100**. The spring is not shown in order to avoid overcrowding figure. The jaw boss **2116** is shown with the jaw projection **2118** in the jaw boss **2116** providing a camming projection for the jaws **2042** when the projection **2118** moves through the actuation slot **2082**.

FIG. **131** is a perspective view of a cam finger assembly **2122**. The cam finger assembly **2122** includes cam fingers **2124** and cam surfaces **2126**. The cam surfaces contact the clip **2000** to push it forward.

FIG. **132** is an isometric, exploded view of the cam finger assembly **2122**. The cam finger assembly **2122** includes the cam fingers **2124**, and the unified portion **2128**. The unified portion **2128** has holes **2129** to accept fasteners **2134**. A cam finger base **2130** attaches to the unified portion **2128** and contacts the clip advance arm **2136**. The clip advance arm **2136** has a notch **2138** for interfacing with the cam finger base **2130**. The cam finger base **2130** has a slot **2132** including to larger diameter portions **2133**. The fasteners **2134** attach the cam finger base **2130** to the unified portion **2128** while still being able to slide within the slot **2132**. The larger diameter portions **2133** may align with the holes **2129** in the unified portion **2128**. A cam finger shim **2140** is also shown.

FIG. **133** illustrates the jaws **2042** in an open position. The cam fingers **2124** have moved forward and would engage a clip **2000** just behind the hinge portion **2016** and in front of the connectors **2034** to bias the clip **2000** and an open position. However, the majority of the clip **2000** itself is not visible from the view shown in FIG. **133**. FIG. **134** illustrates the jaws **2042** and a closed position. The cam finger base **2130** has moved back or proximately as the jaws **2042** closed releasing the cam fingers **2124** from the clip **2000** thereby releasing the clip **2000** in the jaws **2042**.

FIG. **135** shows the jaws **2042** in a closed position. The cam finger base **2130** has moved back pulling the cam fingers **2124** over the clip **2000** just inside the outer tube **2048** and sets into the tabs **2142** in the outer tube **2048**. FIG. **136** illustrates the jaws **2042** just beginning to open as the cam finger base **2130** moves forward camming the cam fingers **2124** to pinch the

clip **2000** open. The cam fingers **2124** are held in place by the tabs **2142** in the outer tube assembly **2048** until the clip **2000** is fully pinched.

The jaws **2042** are in an open position that shown in FIG. **137**. Once the jaws **2042** have opened, the cam finger assembly **2122** moves forward. The cam fingers **2124** push the clip **2000** forward or distally. At the same time the clip **2000** is pushed into the jaws **2042** and opens as it advances into the jaws **2042** and out of the outer tube assembly **2048**.

As shown in FIG. **138**, the clip **2000** is fully advanced into the jaws **2042** by the forward or distal movement of the cam fingers **2124** of the cam finger assembly **2122**.

FIGS. **139** through **144** illustrate a handle assembly **2050** that may be used in accordance with some embodiments of the invention. The handle assembly **2050** is meant to be exemplary only and is in no way limiting. The distal end **2060** (See FIG. **114**) of the applier **2040** can be used with a variety of different handle assemblies are not limited to those shown herein. Furthermore, one of ordinary skill the art can appreciate after reviewing this disclosure that there are many other ways to manipulate the movements of the distal end **2060**. For example, a manually operated handle may be used as well as electro/mechanically operated handles, robotically controlled interfaces and other suitable interfaces may also be used. Mechanical handles that may be used include not only the various mechanical handles illustrated and described in the various embodiments described herein but other mechanical handles may also be used. While the specific attachments between the handle assemblies **2050** in various features of the distal end **2060** are not shown with respect to the embodiments described FIGS. **139** through **145**, these types of connections are shown with respect to other embodiments described herein. Furthermore, other types of these connections may be well known in the art and may be used in accordance with some embodiments of the invention. After reviewing the disclosure made herein, one of ordinary skill the art will understand how to operatively connect the handle assembly **2050** of FIGS. **139-145** to various distal features of the applier **2040**. FIGS. **139** through **145** show the handle assembly **2050** with one of the clamshell housings **2144** removed in order to better show internal parts.

FIG. **139** is an exploded view of a handle assembly **2050**. The handle assembly **2050** includes a handle clamshell **2144**. It will be appreciated that although only one handle clamshell **2144** is illustrated, two handle clamshells are used and are substantially mirror images of each other with minor variations to facilitate attaching the two handle shells **2144** together or to accommodate interior parts contained in the handle shells **2144**. The handle assembly **2050** also includes a pivotal trigger **2146**. The pivotal trigger **2146** may include a pivot hole **2166** and connecting ears **2164**. The handle assembly **2050** may also include a jaw link **2148** and the trigger link **2150**. The handle assembly **2050** may also include a clip lock arm connector **2152** and an advance arm connector **2154**. The advance arm connector **2154** may be made of several parts including an arm cap **2156**, and arm shaft **2158** and a connector arm housing **2160**. The arm cap **2156** may include a slot **2157** into which the jaw link **2148** may fit. The arm shaft **2158** is fit into the connector arm housing **2160** and both are capped by the arm cap **2156**. The handle assembly **2050** may also include a pawl **2162**.

FIG. **140** illustrates the start or default position of the components in the handle assembly **2050**. The rotator **2058** allows a user to rotate the outer tube assembly **2048** and thereby the jaws to a desired angular rotation by merely twisting the rotator **2058**. The trigger **2146** is shown along with its pivot point **2168**. The trigger **2146** is equipped with connecting ears **2164** which connect to a clip lock arm connector **2152** which is operatively connected to the clip lock arm **2072** (not shown in FIG. **140**). The trigger **2146** has a second pivot point **2170**. The second pivot point **2170** is connected to a spring **2172** for biasing the trigger **2146** and a trigger link **2150**. The trigger link **2150** is connected to the jaw link **2148** within the advance arm connector **2154**. The advance arm connector **2154** is operatively connected to the feed tube **2076** (not shown in FIG. **140**). The advance arm connector **2154** is capped by the arm cap **2156**. The spring **2172** urges against the handle shell **2144** on one end and the advance arm connector **2154** and the clip lock arm connector **2152** at the other end. The spring **2174** urges against the feed tube **2076** on one end and the jaw link **2148** on the other end. The springs **2174** and **2176** bias the components of the handle assembly **2054** to the position shown in FIG. **140**. The pawl **2162** is shown in a disengaged position.

FIG. **141** illustrates the handle assembly where the trigger **2146** is moved slightly the direction indicated by arrow B. The movement of the trigger **2146** has caused the jaws **2042** (not shown in FIG. **141**) to close. The jaw link **2148** has moved back in the direction illustrated by arrow A to advance the clip advance arm connectors **2152**. The jaw link **2148** pulls back the feed tube (not shown in FIG. **141**) through a spring.

As shown in FIG. **142**, continued movement of the trigger **2146** in the direction of arrow B causes the clip advance arm connector **2154** to move over the pawl **2162** in the direction of arrow A. The trigger link **2150** pushes the clip lock arm connector **2152** forward causing the clip lock arm **2072** (not shown in FIG. **142**). To move forward and lock the clip **2000** contained within the jaws **2042**. Continued movement of the trigger **2146** in the direction of arrow B the causes the jaw link **2148** within the advance arm connector **2154** to further compress the spring **2174** thereby limiting the amount of jaw **2042** clamping force. In other words, the spring **2174** is part of an overdrive which limits the amount of closing or clamping force the jaws **2042** can exert. Thus, once the trigger **2146** has achieved a particular position, any additional force on the trigger **2146** to continue moving in the direction of arrow B will not cause increased clamping force on the jaws but rather will simply compress the spring **2174**.

FIG. **143** shows the trigger **2146** returning to its initial position in the direction of arrow D. The trigger **2146** returns as result of the biasing from spring **2172**. While FIG. **143** does not show the lower end of the spring **2172** to anchored, one of ordinary skill the art will understand when the second clamshell housing **2244** is installed, the spring **2172** will be anchored similar to that shown in FIGS. **144** and **145**. The return movement of the trigger **2146** causes connecting ears **2164** to move the clip lock arm **2152** in the direction of arrow A. The clip advance arm **2154** is locked in place by the pawl **2162**. The jaw link **2148** and trigger link **2150** are moved in the direction of arrow B through the slot **2178** in the connector housing **2160**.

As the trigger **2146** continues to move to its initial condition in the direction of arrow D, the jaws **2042** (not shown in FIG. **144**) open, the pawl **2162** is tripped and the advance arm **2154** moves forward as illustrated by arrow B.

FIG. **145** shows the components at their initial conditions. The trigger **2146** is at its full forward position the clip **2000** and loaded into the jaws **2042** (not shown in FIG. **145**) the advance arm connector **2154** is in its initial condition along with the trigger link **2150**.

FIGS. **146-148** illustrate another clip **2000** that may be used in some embodiments of the invention. The clip **2000** shown in FIGS. **146-148** is similar to the clip illustrated in

FIGS. **108-113**. Differences between the clip **2000** shown in FIGS. **146-148** include the buttress **2022** having a different exterior geometry. The buttress **2022** is attached the connectors **2034** which, in turn, are connected to the locking wings **2026** of the clip **2000**. The locking wings **2026** have a slightly different geometry as the clips **2000** shown earlier figures but is shaped to correspond to the exterior geometry of the buttress **2022**. The different exterior geometry of the buttress **2022** provides desired locking and unlocking characteristics for facilitating insertion or removal of the buttress **2022** from the locking void **2020**. The clip **2000** also has bulges **2180** mounted on the upper leg **2002** and the rear bottom leg **2004**. In some embodiments, the bulges **2180** assist in the retention and removal of the clip **2000** in the jaws **2042** of the applier **2040**. In other embodiments of the invention appliers **2040** can be used with various shaped clips and are not limited to the various clips described herein. For example, other clips are shown and described in the application titled "Narrow Profile Surgical Ligation Clip" filed Sep. 14, 2012 and identified as U.S. patent application Ser. No. 13/616,120 which is incorporated by reference in its entirety herein.

The many features and advantages of the invention are apparent from the detailed specification, and, thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the true spirit and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and, accordingly, all suitable modifications and equivalents may be resorted to that fall within the scope of the invention. All ranges cited herein specifically incorporate all values and sub-ranges within the cited range.

What is claimed is:

1. An applier for a ligation clip comprising:

an outer tube having mounting bosses, the mounting bosses defining holes;

a pair of jaws pivotally connected to the mounting bosses, the jaws having outwardly extending projections that extend through the holes in the bosses and inwardly extending actuating projections;

a feed tube located in the outer tube and configured to move axially within the outer tube, the feed tube having actuating slots into which the actuating projections extend;

a clip lock arm located in the outer tube and configured to move axially within the outer tube; and

a clip advance arm located in the outer tube and configured to move axially within the outer tube, the clip advance arm having flexible pinchers at one end of the clip advance arm.

2. The applier of claim **1**, wherein the actuating slots are configured to cause the jaws to open when the feed tube is moved in a direction toward the jaws and close the jaws when the feed tube is moved in a direction away from the jaws.

3. The applier of claim **1**, further comprising spring fingers on the feed tube configured to prevent a clip in the applier from moving away from the jaws when the clip advance arm is moving away from the jaws.

4. The applier of claim **1**, further comprising a slot in the feed tube and a portion of the clip lock arm extends through the slot in the feed tube.

5. The applier of claim **1**, wherein the flexible pinchers are configured to move over legs of a clip located in the applier and move the legs to a closed position.

6. The applier of claim **1**, wherein the flexible pinchers are configured to press on a rear portion opposite of legs on a clip to move to legs to an open position.

7. The applier of claim **6**, wherein the flexible pincher press on the rear portion opposite the legs on the clip to an open position when the clip moves into the jaws.

8. The applier of claim **1**, further comprising a spring loaded clip stack pusher configured to urge a stack of clips in the applier to a direction toward the jaws.

9. The applier of claim **8**, wherein the stack pusher is configured to extend into the jaws when there are no clips in the applier.

10. The applier of claim **1**, wherein the clip lock arm is dimensioned and configured to, when moved forward, contact a buttress in a clip located in the jaws and move to buttress forward into a locking void to thereby lock the clip in a closed position.

11. The applier of claim **1**, further comprising a handle having a pivoting lever operably connected to the clip lock arm, the feed tube, and the clip advance arm to move the clip lock arm, the feed tube, and the clip advance arm axially within the outer tube by pivoting the lever.

12. The applier of claim **11**, further comprising a spring biasing the lever to a first position.

13. The applier of claim **11**, wherein the handle further includes a jaw link operatively connected to the feed tube and the lever and actuation of the lever causes the jaw link to move the feed tube to a proximal position and further actuation of the lever causes the jaw link to stop moving the feed tube instead flex a spring.

14. The applier of claim **1**, further comprising recesses at a distal end of the jaws configured to capture ends of a clip to retain the clip in the jaws.

15. The applier of claim **14**, further comprising slanted surfaces defining at least in part the recesses and configured to communicate with slanted surfaces on legs of a clip to retain the clip in the jaws.

16. The applier of claim **1**, further comprising tabs in the outer tube configured to retain the clip advance arm.

17. The applier of claim **1**, wherein the feed tube is dimensioned to store a stack of clips in a closed or semi-closed condition.

18. The applier of claim **1**, wherein the outer tube has a diameter of about 5 mm.

19. An applier for a ligation clip comprising:

an outer tube having mounting bosses, the mounting bosses defining holes;

means for clamping pivotally connected to the mounting bosses, the means for clamping having outwardly extending projections that extend through the holes in the bosses and inwardly extending actuating projections;

means for opening and closing the means for clamping located in the outer tube and configured to move axially within the outer tube, the means for opening and closing the means for clamping having actuating slots into which the actuating projections extend;

means for locking a clip in closed position located in the outer tube and configured to move axially within the outer tube; and

means for advancing a clip located in the outer tube and configured to move axially within the outer tube.

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